2011/2012

Forest Genetics Council of BC

Tree Improvement Program

Project Report

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2011/2012

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Project Report

Introduction and Acknowledgements

Objectives continue to be met by the provincial program led by the Forest Genetics Council of BC (FGC). Operating in its current structure since a major reorganization in 1998, Council has set a strategic vision and formulated objectives through strategic plans, the most recent of which is for the period 2009-2014. These plans have guided subprograms and the development of annual business plans for work that is applied and focused on clear and measurable objectives. Annual reporting provides provincial-level progress measures in FGC Annual Reports and project-level progress in this report. Senior managers in the MFLNRO and the forest industry, as well as the public, have clear measures on progress and access to information through these reports (available at www.fgcouncil.bc.ca). The rigour shown through the business planning and reporting processes has been instrumental in the ongoing support received through the Tree Improvement Program of the Land Based Investment Strategy (LBIS). Tree Improvement investments currently support fully half of the LBIS timber supply objectives through a relatively minor percentage of the overall LBIS investment.

Climate change remains a significant challenge for this program. Forest health and productivity is negatively impacted by climate change because individual trees that are genetically adapted to past climates are now becoming poorly adapted to the climate in which they are rooted. This results in stress and susceptibility to pests, diseases, and other factors. Understanding the patterns of genetic diversity for tree species and developing seed transfer standards that guide operational planting is the primary response to climate change available to forest managers. By better matching the genetic potential of seed used with changing present and future climates, the health and productivity of BC's forests can be supported. Key to this strategy is research to understand the genetic diversity patterns of commercial tree species and how these align with climate. Also key is the development of methods to interpret climates in terms of BC forest ecosystems and how these ecosystems might change over time. Changing seed transfer standards to ensure that seed used is optimally matched to future climates will allow forest managers to better ensure healthier planted forests in the future.

Research on how genetic diversity aligns with climate and on climate model interpretation is well underway in BC. Early provenance testing dating back to the 1960s, and more recent and more specific genecology research, is providing valuable information. With many long-term field trials in place and with models such as ClimateBC, new seed-transfer-standard development is underway. This will not be a one-time change, but rather a new process that will allow updated information to be utilized within a framework of seed transfer that supports operational planting. Changes to seed orchards and to seed inventories held by the private sector and BC Timber Sales are important considerations when developing new seed transfer standards. Significant funding leverage to the LBIS Tree Improvement Program is also being realized with projects such as the UBC-led AdapTree Project funded by Genome Canada. Ultimately these combined efforts will result in better forest health and productivity and a more secure forest-based economy.

A primary strength of this provincial program is the people who work in it. Their dedication and commitment is remarkable and accounts for ongoing program success despite economic challenges within the forest sector. Collaboration for efficient overall delivery is key. The FGC leads this collaboration and provides a structure for people from participating companies and agencies to collaborate through technical committees that focus on specific areas such as seed transfer or genetic conservation. I sincerely thank members of Council and members of all technical committees for their ongoing work.

This publication, in conjunction with the FGC Business Plan and FGC Annual Report, meets the reporting obligations of Council and the LBIS Tree Improvement Program. I would like to thank all project leaders for their contributions.

Jack Woods
Program Manager, Forest Genetics Council of BC
CEO, SelectSeed Ltd.

The Forest Genetics Council Co-chairs invite you to review the programs and projects described in this report and return any questions or comments to:

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Ministry of Forests, Lands and Natural Resource Operations (MFLNRO)
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Further Tree Improvement information can be found at our web sites:

Forest Genetics Council
MFLNRO, Tree Improvement Branch

http://www.fgcouncil.bc.ca
http://www.for.gov.bc.ca/hti
http://www.for.gov.bc.ca/hre/forgen/

BRITISH COLUMBIA
Ministry of
Forests, Lands and
Natural Resource Operations

FGC Forest Genetics Council of British Columbia

Table of Contents

Introduction and Acknowledgements iii
Tree Improvement in British Columbia vii
LBIS - FGC Tree Improvement Subprogram viii
1.0 Expansion of Orchard Seed Supply Subprogram (SelectSeed Co. Ltd.) 1
2.0 Genetic Conservation Technical Advisory Committee (GCTAC) 3
2.1 Centre for Forest Conservation Genetics (CFCG) 3
2.2 Tree Improvement Branch Conservation Activities 4
3.0 Tree Breeding 5
3.1 Coastal Douglas-fir Program 5
3.2 Western Hemlock Forest Genetics Program 6
3.3 True Fir Forest Genetics Program 6
3.4 Western Redcedar Breeding Program 7
3.5 Yellow Cypress Breeding Program 9
3.6 Coastal Broadleaf Species Genetics Program 10
3.7 Interior Douglas-fir Tree Breeding Program 12
3.8 Interior Spruce Tree Breeding Program 14
3.9 Western Larch Tree Breeding Program 15
3.10 Lodgepole Pine, Western White Pine and Interior Paper Birch 16
4.0 Seed Transfer Technical Advisory Committee (STTAC) 20
4.1 Assisted Migration Adaptation Trial (AMAT) 22
4.2 Interior Spruce Climate Change/Genecology 23
5.0 Decision Support Technical Advisory Committee (DSTAC) 24
6.0 Operational Tree Improvement (OTIP) 25
6.1 Orchard Projects 26
6.1.1 Saanich Forestry Centre (WFP) 26
6.1.2 Mt. Newton Seed Orchard (TimberWest) 28
6.1.3 Saanich Seed Orchards 30
6.1.4 Kalamalka Seed Orchards 33
6.1.5 Vernon Seed Orchard Company (VSOC) 35
6.1.6 Grandview Seed Orchards (PRT Armstrong) 36
6.1.7 Eagle Rock Seed Orchards (Tolko Industries) 38
6.1.8 Prince George Tree Improvement Station (PGTIS) 39
6.1.9 Skimikin Seed Orchards 41
6.1.10 Kettle River Seed Orchard Company 43
6.1.11 Sorrento Seed Orchards 45

6.2 Technical Support Programs 46
6.2.1 Increasing Quality, Genetic Gain, and Quantity of Yellow Cypress Cuttings 46
6.2.2 Estimating 2011 Pollen Contamination in Coastal Douglas-fir Seed Orchards 47
6.2.3 Collection of Crop Statistics for Intensive Lodgepole Pine Orchards 48
7.0 Extension Technical Advisory Committee (ETAC) 52
8.0 Seed Orchard Pest Management (PMTAC) 53
Appendix 1 PGC Seed Planning Unit 55
Appendix 2 Tree Species 56
Appendix 3 Author Contact List 57

Tree Improvement in British Columbia

The Forest Genetics Council of British Columbia (FGC) is a multi-stakeholder group reporting to the provincial Chief Forester and representing the forest industry, Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), the Canadian Forest Service, and universities. Council's mandate is to champion forest genetic resource management (GRM) in British Columbia, to oversee strategic and business planning for the provincial Land Based Investment Strategy (LBIS) Tree Improvement Program, and to advise the province's Chief Forester on forest genetic resource management policies. FGC Technical Advisory Committees (TACs) provide technical and policy information to Council and contribute to the development of FGC plans and associated budgets.

Council's vision is that BC's forest genetic resources are diverse, resilient, and managed to provide multiple values for the benefit of present and future generations. This vision is supported by six objectives that are set out in Council's Strategic Plan for the period 2009 to 2014[1] and reported upon annually.

Annual business planning processes are designed to support achievement of the objectives, and the FGC Business Plan defines the annual set of activities and budgets needed to achieve objectives and realize the overall vision.

Forest genetic resource management is a co-operative effort in BC. In broad terms, the MFLNRO tree breeding activities and private companies contribute seed and production to a collaborative effort between MFLNRO and the private sector. The MFLNRO universities and consultants carry out research supporting operational GRM programs.

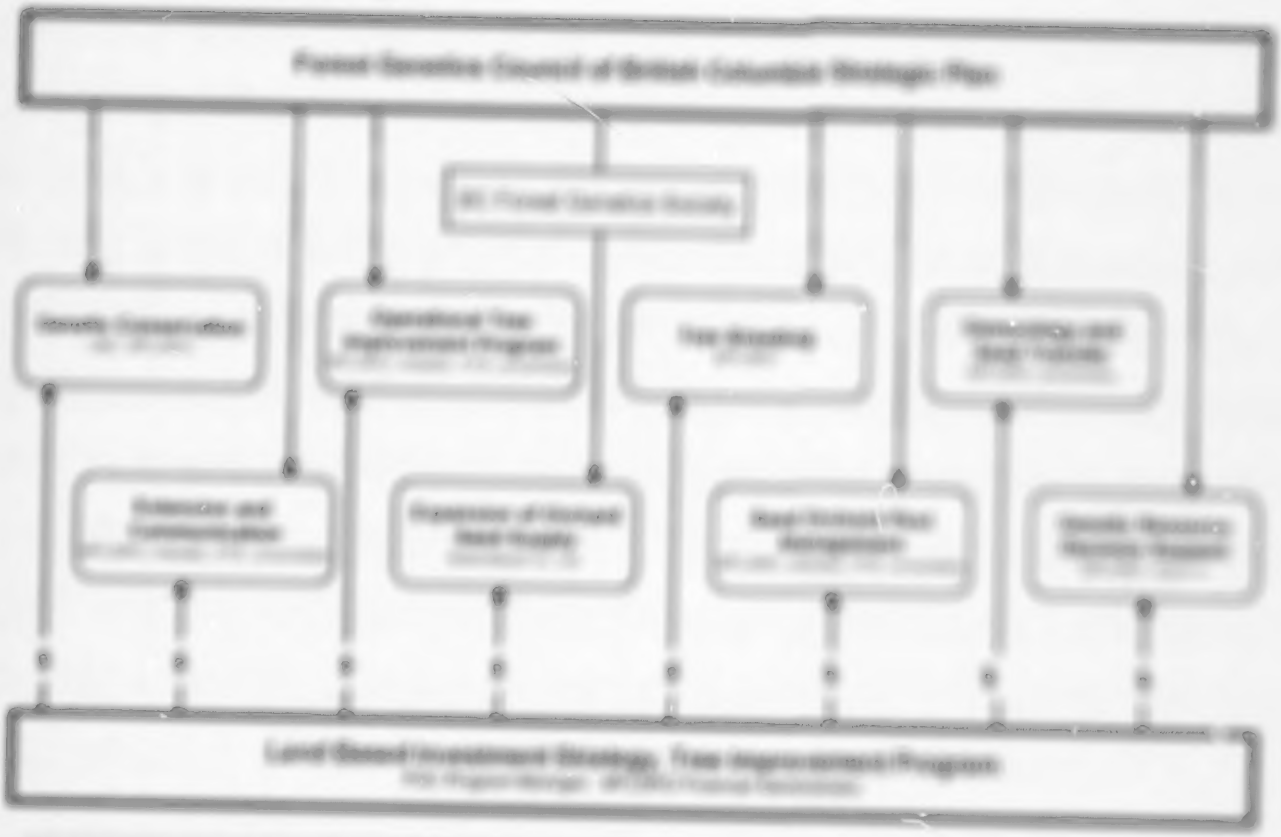
Various technical advisory committees reporting to the FGC facilitate collaboration on a variety of support issues including genetic conservation, climate-based seed transfer, orchard pest management, extension, and records management and decision support.

The Interior and Coast Technical Advisory Committees (ITAC and CTAC) are the primary committees reporting to and informing the FGC. Members are drawn from people involved with GRM activities in BC, as well as operational forestry staff from forest companies or government agencies. The Chairs of the ITAC and CTAC sit as members of Council to facilitate communication and input between the policy and management perspective of Council and the more applied perspective of the TACs. Other technical advisory committees also advise the FGC, but are not directly linked through Council membership. These TACs include Genetic Conservation (GCTAC), Seed Transfer (STTAC), Extension (ETAC), cone and seed Pest Management (PMTAC), and Decision Support (DSTAC).

[1] http://www.fgcouncil.bc.ca/StrategicPlan2010-Layout-Web-120ct09.pdf

LBIS – FGC Tree Improvement Subprograms

[redacted]


Forest Genetics Council of British Columbia Strategic Plan
BC Forest Genetics Society
Operational Tree Improvement Programs
Tree Breeding
Extension and Communication
Genetic Resource Decision Support
Land Based Investment Strategy Tree Improvement Program

[redacted]

1.0 Expansion of Orchard Seed Supply Subprogram Gotechseed Co. Ltd.

Introduction

Overview

Seed Orchard Operations

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2.2 Tree Improvement Branch Conservation Activities

Conservation Catalogue

Charlie Cartwright

Recent conservation catalguing for two species in BC consists of 3 documents.

- Technical Report 050 of Ministry of Forests and Range, Forest Science Program, (Forest Tree Genetic Conservation Status Report 1: In Situ Conservation Status of All Indigenous British Columbia Species by Choumenkovitch et al. 2009) is a general census.
- Technical Report 054 (Forest Tree Genetic Conservation Status Report 2: Genetic Conservation of Operational Tree Species by Krakowski et al. 2009) covers details for timber species that have breeding programs.
- A catalogue is now in development, (Genetic Conservation and Genecological Traits of Minor Indigenous Timber Species), that concerns tree species that have genecology trials and seed transfer guidelines developed. By the end of 2011 12, 6 of 11 such species had been assessed.

Gene Conservation Ex Situ Seed Collection

Priorities for collection are derived from the assessment in Technical Report 050 and targeted species are specified for seed collection. 2011 12 was a mediocre crop year for 6 whitebark pine, 6 limber pine, 3 western yew, 2 juniper, 3 alfalfa and 7 cascara populations were obtained. This is an ongoing project.

Whitebark Pine

Catastrophic decline in many populations, due to impacts of white pine blister rust, mountain pine beetle, fire exclusion, and logging led the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to recommend whitebark pine be listed in 2010 as endangered based on the status report. Approval to add the species to Schedule 1 of the Species at Risk Act (SARA) in June 2011 was given by assent in parliament by the federal government. It was listed in Alberta as Endangered in 2009, it was listed in BC in 2009 as vulnerable (which is the definition of being added to the Blue list).

A meeting of interested persons from agencies including the Federal Government, Alberta Sustainable Resource Development, as well as BC MFLNRO, WRF, universities and NGOs was hosted December 2, 2011 to consider action. A proposal to screen whitebark pinus trees for resistance to blister rust in field trials was developed out of the meeting comments. A version of the proposal was presented to GCTAC for funding and some seed collection and stratification of seed was approved for the year to follow.

Plate 2: Whitebark pine regeneration.

Seed Bank Maintenance

Dave Kolotelo, Tree Seed Centre

TSC efforts have focused on sample consolidation and confirming the moisture status of new in-situ collections was below 10% for freezer storage at -18 °C. Some samples of water birch, Limber pine and whitebark pine were subsequently dried to below the 10% moisture threshold. No germination testing or x-ray analysis was performed on samples in this year.

Genotyping of aspen and grand fir for gene conservation decisions

Richard Weeks, Cheng-Yi Xie, Julie Klutsinski, Charlie Cartwright

Vegetative buds of 20 trees per population for aspen and grand fir were collected for DNA analysis. A total of 13 aspen populations (12 coastal and 1 interior) and 12 grand fir populations (5 coastal and 7 interior) were sampled. DNA analysis using eight polymorphic microsatellite markers is now completed for aspen and 50% completed for grand fir. Genetic parameters, such as allele frequencies, heterozygosities, F-statistics, Nei's genetic distance and Hardy-Weinberg equilibrium conformity/deviations will be estimated/tested and used to make science based decisions on the conservation needs of these two species. The DNA data analysis is underway for aspen and will start for grand fir as soon as the grand fir data are delivered.

Plate 1. The image shows polymorphism between different *Abies grandis* genomic DNA samples using a 6-fam nucleotide microsatellite marker (GP667) developed for this project. The genomic DNAs were amplified by PCR and analyzed by agarose gel electrophoresis alongside a 50 bp ladder size marker. Polymorphic differences in the sizes of the amplified products are evident between different lanes of the gel.

3.0 Tree Breeding

3.1 Coastal Douglas-fir Program

Michael Stoehr, Keith Bird, Lisa Hayton

Fall measurements in 2011 and the subsequent data analysis of Series 3 progeny test (EP708.23) at age 7 resulted in the pre-selection of the best forward selections from the five sublines planted. Forecast to rotation age 60, the average breeding value (bv) of these selections is 15, but it is anticipated that these bv will increase after final measurements (2014) and age-age correlation increases. Roughly 10 scions from the candidate trees were taken in January 2012 from the Big Tree (Campbell River) and Rocklos (Cowichan) sites for early grafting. Series 4 (full-sib test, EP708.24) continues to perform well, after the sites were brushed and weeded (good growth rates and high survival).

A replicated, raised bed trial was established at RBL (Glyn Road lab) to study the relationship between secondary metabolites (phenolics and terpenes) of full-sib seedlings and perennial disease and insect resistance. Growth and phenology data have also been collected from these 40 full-sib families representing trees from the advanced generation Douglas-fir program. Chemical analysis, conducted by the Analytical Lab at Glyn Road, is in progress.

The expected impacts of inbreeding on nursery and growth traits in coastal Douglas-fir are well documented. However, our knowledge of inbreeding effects on non-timber traits, such as wood traits, is lacking. For this reason, we used an established inbreeding trial (EP092, having four different levels of inbreeding) to evaluate wood density and its relationship with levels of inbreeding. Wood cores and growth measurements have been collected and cores are currently being analyzed to determine wood density.

Final selections were made in EP1200, coastal-interior transition zone (sub-maritime, SM) based on age 12 measurements. Data analysis is also underway for this set of measurements to evaluate climate change impacts on the estimation of breeding values of A-class seed. Two superior forward selections from the Talchako test site were added to the list of candidates for the SM orchard of SPU19.

Our co-operation with the Coast Region soil scientist is continuing. The goal of this project is to check if local coastal Douglas-fir provenances have different mycorrhizal community associations than introduced provenances. Furthermore, is the composition of the communities related to type and amount of available nitrogen in the soil? EP599.3 provenance tests are used for this study. Results may have implications for assisted migration.

Regular clone bank and breeding arboretum maintenance continued with the grafting of root-stock compatible parents for the eventual increase in production of graft-compatible rootstock seed needed for orchard expansions and clone bank management.

Publications

Krakowski, J. and M.U. Stoehr. 2011. Douglas-fir Provenance Survival and Growth in the British Columbia South Submaritime Seed Planning Zone. Know. Manage. Br. Nat. Resource Sec., Victoria, B.C. Extens. Note 105.

Stoehr, M.U. and Y.A. El-Kassaby. 2011. Challenges facing the forest industry in relation to seed dormancy and seed quality. Methods Mol. Biol. 773:3-15.

Woods, J. and M. Stoehr. 2011. Seedlot Genetic Worth Values Verified for Coastal Douglas-fir at Age 12. Forest Genetics Council of British Columbia. Factsheet 2.

3.2 Western Hemlock Forest Genetics Program

Charlie Cartwright

The Hemlock Forest Genetics Program of Tree Improvement Branch continues to wind down operations as a consequence of limited planting of the species in BC. Plans developed in a recent program review call for securing investment in the field trials by "putting them to bed". This involves removal of ingress, upgrading tree tagging and access notes, as well as making a final data collection. The data will be used to develop new or revised breeding values for the current seed orchards, as well as document genetic gains as demonstrated in realized-gain trials.

This year for SPU 3 (Low Elevation Maritime) maintenance was carried out on 9 trials and 5 were measured as planned. New preliminary breeding values were calculated for 93 parent trees, but figures from more mature trees were not analyzed in this fiscal year because the data did not arrive until late March.

The breeding arboreta were dismantled, but clone-banking of over 50 important selections was done as per plan. Due to poor survival in the established clonebanks, (even of well established ramets), a new secure area is being developed for most valued selections. (Many of these are from American sources and may not be available in the future as jurisdictions and ownerships shift). Attention was also given to realized-gain installations this year as the effort is made to verify the tree improvement already in the existing orchards.

For the High Elevation Maritime, (SPU 24), 4 trials were maintained of the 6 planned due to the early arrival of snow. For this reason as well, data collections and analysis were postponed. Consequences of delaying measurements for the installations at higher elevations are less substantial due to the slower growth rates. We anticipate that activities for this single generation improvement program will be wrapped up in the next few years.

3.3 True Fir Forest Genetics Program

Charlie Cartwright

Work with the true firs involves the 4 species planted in the province, for which there are genecology tests. With Pacific silver fir as well as subalpine fir, programs have only been undertaken in the last 10 years, so there are numerous treatments required on these younger installations.

Maintenance was planned for 4 amabilis test sites, but due to quick recovery of brush, 7 needed to be treated. As well, measurement of 5 sites had been arranged, but extra work was initiated to take advantage of other activities adjacent to our sites leading to data collection for 3 additional trials. Permanent labels were also installed on one of the sites. The growing database for this species should allow for adjustment of seed transfer rules soon, while work towards climate-based seed transfer guidelines continues.

Similarly for subalpine fir maintenance was necessary on 11 trials, 3 more than planned, due largely to brush recovering from previous treatments more quickly than anticipated. As well as the maintenance, one older trial was measured and another one tagged.

For the more mature projects, work focused upon measurements or preparing for them. Four grand fir test sites were measured for age 30 years height and DBH as planned. Analysis of the data will be completed and a report written. Site selection for this series of tests was particularly good and growth has generally been impressive. The tallest tree was 40 m and the thickest exceeded 0.7 m DBH. Little further work is anticipated with these trials in the near future, but based on the results seed transfer guidelines can now be adjusted and areas for B+ seed collection identified.

For noble fir access notes were updated and some maintenance was done on 4 different test sites in preparation for upcoming age 30 year measurement.

3.4 Western Redcedar Breeding Program

John Russell and Craig Ferguson

Our objective for the western redcedar breeding program is to develop a durable advanced generation population with potential cross resistance, or at least positive genetic correlations among resistance traits. Developing breeding populations that are resilient to multiple pests may not only give protection against the current target pests but potentially against future unknown ones. Growth and cedar leaf blight (CLB) intensity are significantly correlated, and selections for increased volume production and CLB resistance are easily achieved. Genetic correlations between secondary extractives in the foliage and growth rate, and secondary extractives in heartwood and the foliage, although not strong, are positively low to moderate, allowing us some good potential for independent culling in future selections. Although this is certainly a simplistic measure and assessment of complex chemical pathways, it does give us a potential indication that there is minimal competition in chemical resources between foliage and heartwood extractives.

The first generation improvement program focussed mainly on selection for growth with some emphasis on heartwood durability through enhanced secondary extractives. The deer resistance program, which was developed after the other traits were already under selection, has been directed at elevating foliage monoterpene concentrations. This was achieved through rapid generation turnover, high selection intensity and early greenhouse testing. There was minimal information from the other populations to incorporate multiple trait selection. We currently have no information on CLB resistance mechanisms but as in many leaf disease studies, foliar monoterpenes have been implicated.

Because of the partial confounding of population with selection objectives in the first generation of screening, we are currently establishing clonal trials with a combined multi-trait objective in each of the growth/CLB and the deer resistance populations. For the growth/CLB traits, advanced generation matings from backward selections have been completed for the first four series of polycross testing (there are a total of seven). Seedlings from approximately 150 families were sampled for foliage monoterpenes in the greenhouse, winter 2011, and high monoterpene selections have been cloned through rooting. These clones will be bulked-up to produce enough cutting material for clonal testing for growth/CLB resistance across a number of environments. A second set of families were sown in 2012.

For the deer resistance population, one-year-old seedlings from second generation full-sib breeding have already been tested for foliar monoterpenes and forward selections cloned for production hedges. Approximately 60 of these deer resistant clones were established in four environments conducive to good growth (two in Powell River) and cedar leaf blight (two on north Vancouver Island). Another set will be established in 2014.

Selections for advanced generation breeding will be separated into partial diallels grouped by traits, and matings performed within and between groups (Plate 4) with assortative mating within groups.

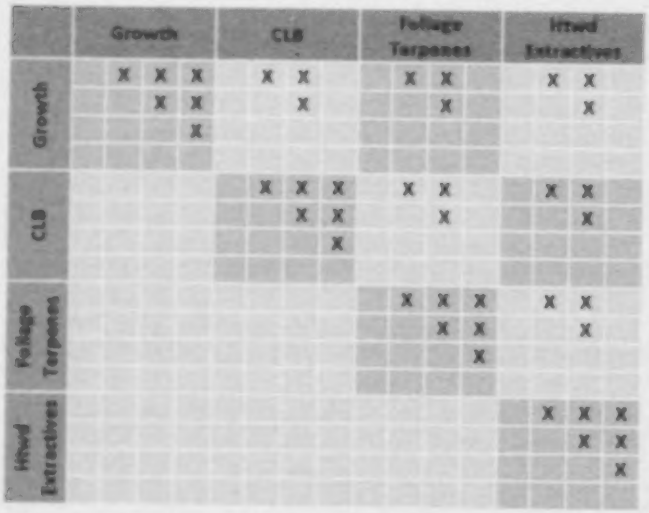

Plate 4. Western redcedar advanced generation breeding strategy for multiple pests and growth.

In order to achieve an effective population size of around 100, the final population will be composed of: 1) 50 3rd generation forward selections from the deer resistant population further clonally selected for growth and CLB resistance; 2) 50 first generation parental selections based on clonal values for total heartwood extractive content with selections removed with poor parental volume breeding values and foliar monoterpene parental clonal values (independent selection), and; 3) 50 2nd generation forward selections for volume, further selected for deer resistance. It will most likely not be necessary to include parents selected primarily for CLB resistance since all volume selections will be resistant to CLB and the deer population will be further tested for resistance. Currently, mechanisms for CLB resistance are unknown but being researched. It may be appropriate to make additional selections based on future potential resistance mechanisms.

Plate 5. High terpene western redcedar clones for cutting production.

Deer resistant seedlots and veglots are currently being made available to industry on a limited basis for operational deployment trials. The seedlots come from polycrossing high terpene parents and the cuttings come from high terpene clones greenhouse grown in containers (Plate 5). The first set were grown at Sylvan Vale nursery and planted out on central Vancouver Island in cooperation with TimberWest. The second set, also grown at Sylvan Vale will be planted out by Western Forest Products spring 2013. These plantings will be monitored over the next few years to determine if browsing is reduced with mixtures of resistant seedlings and rooted cuttings. In addition, two short-term deployment trials were established at Cobble Hill (Plate 6) and CLRS in 2011 and six more are planned for winter 2012.

Six new interior western redcedar provenance trials were established in the in spring 2011; two in the East Kootenays, one east of Golden, two in the Rocky Mountain Trench, and one north of Prince George. Seed has been sown and sites selected for two more trials in the northern ICH near Hazelton.

Plate 6. Deer feeding choice study at Cobble Hill 2011.

3.5 Yellow Cypress Breeding Program

John Russell and Craig Ferguson

This program is currently focussing on maintenance and measurements of the clonal full-sib field trials. A select clonal population with a genetic gain of 20% volume has been established with serial propagated donors in greenhouses at CLRS. This elite veglot has the potential to be 35% greater in early height as compared to wildstand seedlots across a wide range of ecosystems within the yellow cypress maritime SPU. In addition, approximately 100 forward clonal selections based on growth and form will be established at CLRS for archiving and future advanced generation breeding.

Twenty year measurements from the range-wide yellow cypress provenance trial were collected in 2012 (Plate 7).

Plate 7. Twenty-year-old yellow cypress in a provenance trial at Champion Lake near Castlegar.

3.6 Coastal Broadleaf Species Genetics Program

Chang-Yi Xie, Lisa Hayton and Keith Bird

Red Alder

Seed orchard establishment

Seed orchard establishment is well underway at MFLNRO Saanich Seed Orchard.

Reproductive biology study

A red alder reproductive biology study has been completed. It was found that male catkins should be collected for pollen forcing only if the catkin does not break when completely bent in order to produce adequate amount of good quality pollen.

Collected male catkins should be placed into paper bags and forced to shed pollen for 24 to 40 hours at 15-18°C. Paper bags with catkins should be placed on mesh type shelving or on a counter with elevated mesh under the bag to allow air flow under the bag. Pollen should be dried for a maximum of 4 hours at 16-18°C until it flows freely and does not lump. For short-term storage up to 2 days, dried pollen should be placed in vials and into a refrigerator at 2-4°C. For longer storage during the current breeding season, pollen in vials should be stored in a freezer. For storage over a year, pollen should be vacuum sealed and stored at about -18°C. There is no definite indication of full female receptivity and its duration as is in conifer species.

Plate 8. Grafted red alder plants in greenhouse ready for seed orchard establishment.

Plate 9. Red alder male catkin readys for pollen shedding.

Breeding

In the spring of 2012, pollen was collected from the top 14 clones in the clone bank to formulate 15 poly-mixes: 14 specific poly-mixes with 13 pollen clones excluding selfing pollen, and 1 general poly-mix with all 14 pollen clones to pollinate the rest of the unrelated clones. The same poly-mixes were used for both control and supplemental mass pollination (SMP). Breeding was conducted on 39 clones.

Plate 10. Red alder breeding experiment.

Black cottonwood

Provenance-clonal testing

The 6-year and 4-year assessments have been completed at Terrace and Harrison sites, respectively. The southern sources were 70% superior in growth at both sites. In addition, there are some native cottonwood clones that demonstrated equal or superior performance as compared to operationally planted hybrid poplars.

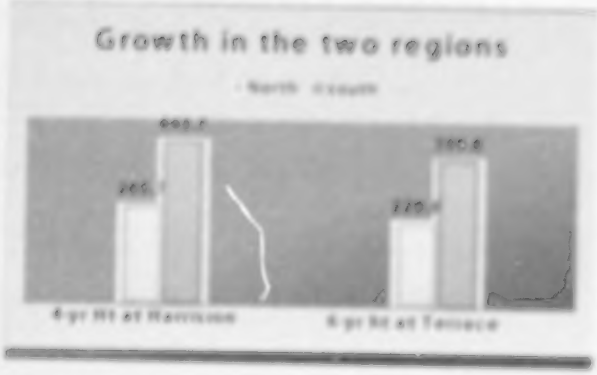

Plate 11. Southern sources are superior (70%) in both regions.

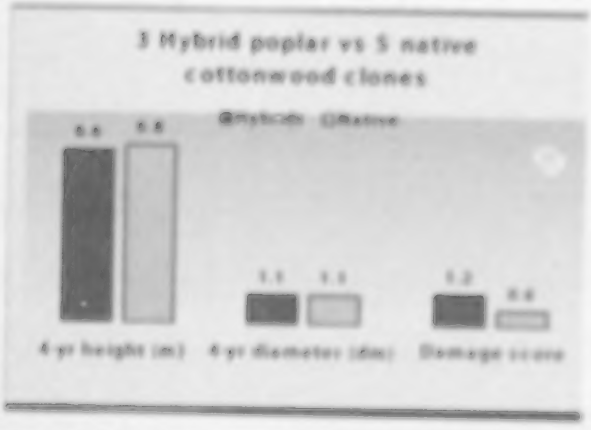

Plate 12. Superior native cottonwood clones are available.

Clone bank establishment

A total of 135 clones were selected based on their superiority in growth, form and health conditions at the Harrison site. Cuttings will be collected, and planted at Saanich Seed Orchard next spring.

Bigleaf Maple

Due to the closure of the Kruger Forest Products Nursery at Harrison and high mortality we abandoned the trial at Kilby-Cassy Island. The other 3 trials are well maintained and trees started to take off.

Plate 13. Keith Bird at 3-year bigleaf maple site near Powell River.

3.7 Interior Douglas-fir Tree Breeding Program

Barry Jaquish, Val Ashley, Colette Phillips and Bonnie Hunge

The BC Interior Douglas-fir tree breeding program began in 1982 with the objective of producing improved and genetically diverse seed for planting on productive forest lands in south-central BC. Within this wide-ranging and ecologically diverse land base, six seed planning units (SPUs) were delineated for tree improvement. The first cycle of breeding in each SPU was based on: 1) phenotypic selection in wild stands, 2) establishment of grafted breeding orchards and clone banks, 3) progeny testing using open-pollinated (OP) seed collected from wild-stand trees, 4) delayed-clonal seed orchards backward selection early progeny test results, and 5) controlled mating to produce pedigree material for second-generation selection. The breeding goal is to improve traits related to tree size (height, diameter and volume) while maintaining wood relative density near old growth values. Moreover, the recent discovery of resistance to Armillaria root disease in Interior Douglas-fir suggests that resistance to Armillaria could become an important trait of interest. The first-generation progeny testing program includes 1,466 OP families and 33 test sites across the six SPUs.

Seed orchards were established for each SPU in the north Okanagan in the early 1990's and are starting to come into production (Plate 14). In 2013, approximately 3 million of the 9.4 million Interior Douglas-fir seedlings planted in BC came from seed orchards. In 2010, selected parent trees from southern SPUs were identified to establish new 1.5 generation seed orchards for the Thompson Okanagan high and low elevation SPUs. The Thompson Okanagan region was excluded in the program's early stages because of low site productivity; however, recent increases in planting numbers combined with severe seed shortages for the area necessitates the establishment of orchards for these lands.

The second-generation crossing program focuses on the Nelson SPU and includes selected parents from the old West Kootenay, Shuswap Adams and Mica regions. Moreover, since inter-varietal (coastal x interior Douglas-fir) hybrids have shown to be hardy and fast growing in the Nelson low elevation zone, the Nelson second-generation breeding population has been augmented with 16 high breeding value parents from the BC coastal breeding program and 16 forward selections from superior Submaritime provenances in the Trinity Valley range-wide Interior Douglas-fir provenance test.

Unfortunately, the 2010 flower crop was poor and only 7 controlled crosses were completed and 58 pollen lots were collected, processed and stored for future breeding. Controlled crossing for the Nelson SPU remains at about 80 percent complete. In fall 2013, maintenance and measurements were completed on 11 sites (four 25-year-old West Kootenay Low sites, three 25-year-old Cariboo Transition sites, and four 20-year-old East Kootenay sites). Data analyses are in progress.

In addition to the progeny test measurements, several supportive research sites were maintained and assessed. In the 20-year-old Douglas-fir coastal/interior transition adaptation trial at the Skimikin seed orchard, inter-varietal hybrids between coastal and interior parents were approximately 30 percent larger in volume than local Shuswap Adams seedlots. Twenty-five year measurements were made on the Douglas-fir seedling/cuttling (rooted cutting) comparative trial (Plate 15). In this trial, seedling and cuttling planting stock were produced from 23 open-pollinated families and planted in a replicated split-plot trial at the Barnes Creek clone bank. After 25 years, overall differences between the two stock types were non-significant for tree height, diameter and volume. Family mean correlations for the seedling and cuttling ecotypes were significant for tree height ($r=.61$), diameter ($r=.53$) and volume ($r=.42$) suggesting that family growth performance was similar between the two stock types. Three sites in the 15-year-old submaritime Douglas-fir provenance study were maintained and measured, and two sites in the two-year-old Peace River Douglas-fir study were brushed.

The cooperative BC MFLNRO/Forestry Canada Pacific Forestry Centre (PFC) program to screen Interior Douglas-fir parents for resistance to Armillaria root disease continued in 2013/12. New greenhouse facilities for the project were constructed at the Kalamalka Forestry Centre and paper birch (*Betula papyrifera* Marsh.) stems were collected in a natural stand at the Barnes Creek clone bank. The stems were transported to PFC, Victoria where they were cut into approximately 8,000 high quality and consistent dormant blocks approximately 3.5 – 4.0 cm in diameter, 10 cm long and weighing about 225 grams. Approximately 6,700 of these blocks were prepared, inoculated and stored in plastic bins at PFC until blocks are fully colonized (Plates 16 and 17). Screening is expected to begin in spring 2014.

Xiao-Xin Wei, Ivan Scotti-Saintagne, Damone P. Glaser, Jordi Vargas-Hernandez, Javier López-Upton, Barry Jaquish, Ivan Scotti-Saintagne. 2011. Range-wide chloroplast and mitochondrial DNA imprints reveal multiple lineages and complex biogeographic history for Douglas-fir. Tree Genetics and Genomes. DOI 10.1007/s11295-011-0392-6.

Krutovsky, L. P. von Aderkas, S. Owens, B. Jaquish, J. Woods and S. Abrams. 2011. Effects of stem girdling on cone yield and mitigation by phytohormones and metabolites in developing long shoots of Douglas-fir (Pseudotsuga menziesii). New Forests. DOI 10.1007/s11056-011-9294-4.

3.8 Interior Spruce Tree Breeding Program

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2.2 Western Larch Tree Breeding Program

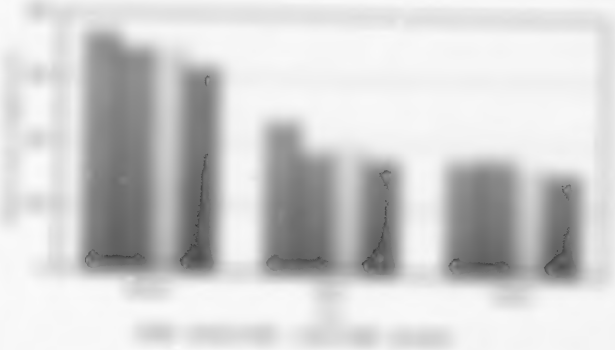

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Photo 25. Selected trees from the "know zone" at the Skeetchestn Seed Orchard site.

Photo 26. The Age-Related Resistance Trial (ARRT) at the Skeetchestn Seed Orchard site with protective fence from white-tail deer.

In 2005, two realized gain trials were established in the north Okanagan to evaluate the resistance estimate given to seed orchards. Currently, seed orchards in the interior are given a rating of 0.9 which indicates that 90% of trees are expected to survive to resistance when exposed to moderate levels of blister rust inoculum. The trees have very little to no blister rust infection after 7 years in the field. They were measured for height growth and assessed for signs of blister rust.

We are continuing work with the ARRT (Age Related Resistance Trial) which investigates the prospect of ontogenic resistance in white pine. Ontogenic resistance is the development of resistance with age. The trial was established at the Skeetchestn Seed Orchard site and includes 7 families and 4 age classes. The trees have been protected from blister rust spores since establishment in 2009 (Photo 25). This year, several Ribes plants were vegetatively propagated at the Kalamalka Forestry Centre and will be used to inoculate the ARRT in 2015.

Coastal Western White Pine Prog

The coastal western white pine breeding program has successfully incorporated local tested material with tested material from Oregon and Washington. After many years of collaboration with industry and the Canadian Forest Service, a formal F1 breeding program was initiated to take advantage of information gathered about local sources and families. Great effort was made to find the original parent tree selections in natural stands for breeding and pollen collection. The natural stand parent trees were ranked based on screening data and crossed to create a population of F1 progeny. Using collaborations with researchers in the United States, several control crossed families were acquired for testing in BC. The progeny of BC and US origins were deployed in 3 series of field trials on Vancouver Island, Tenedo Island and the Sunshine Coast; the seed for a fourth series of F1 progeny tests is also available. These progeny tests will be a source of resistant and tolerant material for current and future seed orchards on the coast.

The coastal western white pine breeding program was greatly affected by retirements and the latest round of job cuts. After the white pine program review of 2010, it was decided that both the interior and coastal programs would be managed by a single breeder. However, given the abrupt change in project leadership, the complexity of the white pine program and the strain on the resources of the Genetics group, it was decided that a contract for the management of the coastal white pine program would be issued. This contract has allowed us to maintain the

continuity and integrity of the coastal white pine program while ensuring a period of knowledge transfer between experts in the field and the new project team.

This year, the first series of F1 field trials was measured for height growth and assessed for blister rust infection. The sites were checked for maintenance requirements and were dealt with accordingly. The data was promptly analyzed and a series of forward selections were made from families with high rust resistance and tolerance. Scion was collected in the winter and grafted this spring. This material will be incorporated into coastal white pine seed orchards.

Interior Paper Birch

The interior paper birch genetics program consists of three tree series which assess several provenances and families across a wide range of test sites. EP 1088.11 tests 19 provenances collected across the range of interior paper birch on 6 test sites from Kaslo to Cranbrook. EP 1088.12 was located at the Skimikin Nursery and contains open pollinated families collected from 19 stands in the Kootenay Region. EP 1088.13 is an elaborate genecology study planted on three test sites (Prince George, Skimikin and northern Idaho) and contains several latitudinal, longitudinal and elevational transects.

There were no significant funds spent on the interior paper birch genetics program this year.

Ponderosa Pine

The ponderosa pine genetics program consists of one well designed provenance test established in 1992 on two sites in the north Okanagan. The test includes provenances from throughout the range of ponderosa pine in BC and the northern United States. After several years of measurement and data analysis, the provenance test site at the Skimikin Seed Orchard was converted to a seed orchard for operational seed production. Little seed has been produced and a component of the orchard was moved to the Bailey Seed Orchard site in Vernon. The data collected from these provenance tests will help us to assign pseudo-breeding values for parent trees in the orchards and develop seed zones. They can also serve as a source of material for future progeny tests.

There were no significant funds spent on the ponderosa pine genetics program this year.

Hybrid Poplar

The hybrid poplar genetics program was designed by Mike Carlson to investigate the possibility of selecting fast growing poplar trees with tolerance to northern climates. Carlson collaborated with Toby Bradshaw at the University of Washington and in the 1990s sent *Populus trichocarpa* material from sources in the interior (Kamloops to Prince George). Crossing was conducted between BC clones and those in the Washington program and some were delivered back to BC. These clones were derived from crosses involving one or two northern parents. Approximately 70 clones were retained in a stool bed in Vernon for many years, however, several were lost to vegetative competition and other factors. Fifty-five were salvaged and used for testing in a common garden experiment at the PRT nursery site at Red Rock near Prince George. Several clones were selected for superior growth and minimal cold damage. Cuttings were collected in 2011 and are now available from a stool bed located at the Skimikin Seed Orchard site.

4.0 Seed Transfer Technical Advisory Committee

Lee Charleson

The Seed Transfer Technical Advisory Committee (STTAC) continues its work developing priorities in genecology research, vetting project proposals and providing budget recommendations to FGC for genecology and seed transfer research.

Funding of ministry genecology projects is done in accordance to the Genetics Section STTAC Strategy, 2011-2016, dated January 31, 2012. As each project progresses, a short lay summary is expected and will be included in this Tree Improvement Program Project report.

The TAC continues with an open call-for-proposals which is intended for innovative ideas to be tried and tested beyond the ministry genecology work.

Genecology projects are reported in several sections of this report. For specific project information refer to the following sections: Centre for Forest Conservation Genetics, Tree Breeding and in the remainder of this section.

J Marty Kranabetter

In 2010-2011, Marty Kranabetter led a project funded by STTAC titled "Coevolution of ectomycorrhizal fungal communities with local provenances of coastal Douglas -fir and the implications for assisted migration". In the following year, a report was prepared and submitted for publication, the abstract for the paper is provided below and the reference is:

Kranabetter, J.M., M.U. Stoehr., and G.A. O'Neill. 2012. Divergence in ectomycorrhizal communities with foreign Douglas-fir populations and implications for assisted migration. Ecological Applications 22: 550-560.

Assisted migration of forest trees has been widely proposed as a climate change adaptation strategy, but moving tree populations to match anticipated future climates may disrupt the geographically-based, coevolved association suggested to exist between host trees and ectomycorrhizal fungal (EMF) communities. We explored this issue by examining the consistency of EMF communities among populations of 40 year-old Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) trees in a common garden field trial using four provenances from contrasting coastal climates in southwestern British Columbia. Considerable variation in EMF community composition within test sites was found, ranging from 0.38 to 0.65 in the mean similarity index, and the divergence in EMF communities from local populations increased with site productivity. Clinal patterns in colonization success were detected for generalist and specialist EMF fungal species on only the two productive test sites. Host population effects were limited to EMF species abundance rather than species loss, as richness per site averaged 15.0 among provenances and did not differ by transfer extent (up to 450 km), while Dr. Shannon Berch's diversity index declined slightly. Large differences in colonization rates of specialist fungi, such as *Tomentella stuposa* and *Clavulina cristata*, raise the possibility that EMF communities maladapted to soil conditions contributed to the inferior growth of some host populations on productive sites. The results of the study suggest locally-based specificity in host-fungal communities is likely a contributing factor in the outcome of provenance trials, and should be a consideration in analyzing seed transfer effects and developing strategies for assisted migration.

D. Scott Green and Hardy P. Griesbauer

This project was funded to undertake work in interior Douglas-fir dendrochronology in 2011-2012. The title of their work is "Assessing the utility of dendroecology in projecting critical seed-transfer distances of interior Douglas-fir in British Columbia".

Development of effective systems of climate-based seed transfer and assisted migration requires a good understanding of how trees from various regions (i.e., populations) will grow in future climates (Wang et al. 2010). Ecological genetics studies using provenance tests have quantified the effects of provenance and site climate on population response traits by developing response and transfer functions. Traditionally, response and transfer functions have modelled environmental and genetic effects of climate on response traits such as cumulative height and volume. These traits provide a single measurement representing accumulated response at a given age. The historical records of inter-annual radial growth patterns studied by dendroecologists provide an additional response trait that can be used to develop similar functions, with some advantages (e.g., cost effectiveness, capacity to exploit natural environmental gradients, the compatability with development of recent spatiotemporal climate models).

We undertook a reanalysis of previously collected Douglas-fir climate-growth responses (Griesbauer and Green 2010) in mature stands over wide climatic conditions in BC to explore the potential to develop a coherent universal transfer function (UTF – Wang et al. 2010). The strong relationships between Douglas-fir climate-growth responses over climatic gradients allowed us to successfully develop such a UTF. The main application of this UTF is in predicting future growth responses in wild populations, and identifying populations of potential concern.

Dendroecological approaches show promise in addressing questions related to climate-induced productivity changes and climate-based seed transfer, and we recommend further study, with certain considerations: 1) Differences in productivity should be quantified using measured stand-level attributes. 2) With respect to climate-based seed transfer, it is also important to consider that transfer limits may be linked to factors associated with tree developmental stages, which is not possible to identify in studies such as this which use mature individuals. 3) The success of this project appears to be related to the extremely wide climate range sampled by the initial project. Project results, implications and recommendations for future research will be detailed in an upcoming publication.

References

Griesbauer, H.P. and D.S. Green. 2010. Regional and ecological patterns in interior Douglas-fir climate-growth relationships in British Columbia, Canada. Can. J. For. Res. 40: 308-321.

Wang, T., G.A. O'Neill, and S.N. Aitken, 2010. Integrating environmental and genetic effects to predict responses of tree populations to climate. Ecol. Appl. 20, 153-163.

4.1 Assisted Migration Adaptation Trial (AMAT)

Greg O'Neill, Vicky Berger, Nick Ukrainetz, Michael Carlson

The AMAT is a long-term field trial of orchard seedlots that will help refine seed source selection to ensure that plantations are adapted, productive and healthy well into the future. Twelve sites are being established for each of four years with seed from orchard seedlots in BC and neighbouring states. Assessment of growth and health will begin in 2013 when the first series of trials is 5 years old.

During fiscal 2011/12, the third series of 12 sites was established, with sites ranging from Whitehorse to Sacramento, California. Seedlings for the fourth and final series were sown, grown and lifted; and sites for the fourth series were identified. Formal agreements with American collaborators were completed. Seedling phytosanitary and import permits were arranged by Michael Carlson, who also coordinated seedling transport.

Considerable effort was devoted toward extension activities in fiscal 2011/12. The project was presented or discussed at the following meetings, tours or publications:

AMAT bulletin (August 2011)
Discover Magazine (June 2011)
Revelstoke News (August 2011)
Revelstoke Forest History Association (August 2011)
William's Lake Tribune (September 2011)
Northern Arizona University (December 2011)
Western Forest Genetics Association – Troutdale, OR (July 2011)
Pacific Climate Impacts Consortium – Victoria (November 2011)
Forest Nursery Association of BC – Salmon Arm (September 2011)
Canadian Institute of Forestry – Campbell River and Port McNeill (March 2012)
Western Forest Insect Working Committee – Penticton (March 2012)

Two articles were published in fiscal 2011/12 on assisted migration in which the AMAT was discussed:

Leech, S., P. Lara Almuedo and G.A. O'Neill. 2011. Assisted Migration: adapting forest management to a changing climate. Journal of Ecosystems and Management 12:18-34. *http://jem.forrex.org/index.php/jem/article/view/91/98*

Pedlar, John H., Daniel W. McKenney, Jean Beaulieu, Stephen J. Colombo, Jason S. McLachlan and Gregory A. O'Neill. 2011. The implementation of assisted migration in Canadian forests. Forestry Chronicle 87 (6) 766-777.

The AMAT team is collaborating with researchers on mycorrhizae projects at UNBC and UBC and on a seedling physiology study at Oregon State University. The AMAT team thanks its many collaborators who have kindly provided advice, seed and test sites, and looks forward to developing further collaborations. For more information on the AMAT see http://www.for.gov.bc.ca/hre/forgen/interior/AMAT.htm.

Plate 24. Lodgepole pine seedling from Montana in newly established AMAT site near Salmon Arm. (photo Vicky Berger)

4.2 Interior Spruce Climate Change/ Genecology

Greg O'Neill and Barry Jaquish

Background

Despite the high value of interior spruce and its wide use in reforestation in BC, good provenance data has been lacking for this species. The interior spruce climate change/ genecology trial (E.P. 670.71.12) was established to address this gap.

The project is unique throughout the world in its size (74,000 trees), number and range seed sources (128 wild and selected populations ranging from -6.2 to 7.3°C MAT and from 289 to 3614 mm MAP), and number and range of test sites (18 test sites from -3.7°C to 9.1°C MAT, and from 340 mm to 2448 mm MAP). The combination of many sources and test sites and wide climate ranges of sources and test sites offers unprecedented ability to predict seed lot performance across a wide range of current and future climates. The trial was awarded start-up funding ($50,000) from Forestry Sector Adaptation Strategies funding program of the Climate Change Impacts and Adaptation Directorate of Natural Resources Canada.

Objectives

To develop a better understanding of the climate responses of Class A and B seed sources of interior spruce and use this information to refine seed transfer and assist the migration of spruce.

Methods

Seedlings from 99 Class B and 29 Class A seed sources from BC, NWT, AB and neighbouring states were outplanted in 2005 at 18 locations in BC, YK and AB. Growth data was collected at ages 3 and 6, and will be collected at ages 10 and 15. Weather stations were established in 2010.

Growth and survival data of all Class A and B seed lots at each site will be submitted to TASS and rotation-age area-based volume will be estimated for each seed lot at each site. Response functions predicting productivity as a function of several site climate variables will be calculated and used to estimate critical seed transfer distances for each seed source. This information will be used to revise climate-based seed transfer system to identify the class A and B seed lots that maximize productivity in every climate.

Deliverables

Height, survival and condition codes on each tree in electronic format.

A report summarizing the data, response and transfer function development, and proposed refinements to climate-based seed transfer system will be developed after 10-year measurements are obtained.

2011/12 Activities

Weather data was downloaded and site maintenance performed. Collaborators with Yukon Department of Natural Resources and Alberta Forest Service were trained to download and maintain weather stations so that they can take over this function.

Age-6 growth data collected in fall 2010 was analyzed and reported on at several meetings or tours (see below). Next data collection will be in fall 2014 at age-10.

The Sx CC/genecology test sites at Skimikin and Kalamalka are being used regularly for demonstration purposes for visiting scientists, student and community groups, Forest Service executive and politicians.

Considerable effort was devoted toward extension activities in fiscal 2011/12.

The project was presented or mentioned at the following meetings or tours:

Northern Silviculture Committee – Mackenzie (June 2011)
Western Forest Genetics Association – Troutdale, OR (July 2011)
Revelstoke Forest History Association – (August 2011)
World Forestry Institute fellow (Saunders) – Kalamalka (August 2011)
Minister of FLNRO (Steve Thomson) – Kalamalka (August 2011)
Chief Forester (Dave Peterson) – Kalamalka (September 2011)
Forest Nursery Association of BC – Skimikin (September 2011)
Vancouver Island University and European Union students – Kalamalka (October 2011)
Director Inland Empire Tree Improvement Coop – Kalamalka (November 2011)
Northern Arizona University – (December 2011)
Canadian Institute of Forestry – Campbell River and Port McNeill (March 2012)
Interior Technical Advisory Committee – Vernon (January 2012)
Okanagan College student tour – Kalamalka (March 2012)

5.0 Decision Support Technical Advisory Commitee

Susan Zedel

The Decision Support Technical Advisory Committee (DSTAC) commenced its first year of projects in 2011-2012, following approval of the committee's terms of reference in March 2011. The DSTAC is responsible for identifying the needs for clients, exploring decision support options, developing proposed work and recommending projects and a budget to the FGC for approval and support. The committee works closely with Tree Improvement Branch on project management and development of decision support tools.

The first project of 2011-2012 was to complete the Mountain Pine Beetle Impact Mapping project reported on in the 2010-2011 project report. Details on this project are available on the Tree Improvement Branch website at http://www.for.gov.bc.ca/hti/seedplanning/MPB_Impact_Opportunity.htm. A cone collection opportunity map was produced for the Mackenzie Timber Supply Area (TSA) in 2011-2012. Maps were created the previous year for the Williams Lake TSA and Quesnel TSA. These maps were developed to assist forest managers to collect lodgepole pine cones from natural stands in areas for which no orchard production exists.

The second project funded by the FGC through the DSTAC in 2011-2012 included the investigation and design of a system to calculate and store seedlot 'area of use' spatial geometry. Once the project is completed in the 2012-2013 fiscal year, clients will be able to view the spatial seedlot 'area of use' polygons using SeedMap, Mapview, ArcGIS and new decision support tools yet to be developed. Queries and reports on deployment of seedlots in specific openings and across the landscape using spatial data will be developed using this new data.

The DSTAC recommended the creation of a Sharepoint site where all genetic resource practitioners and clients can share information. The Sharepoint site 'SeedTalk BC' was created as a discussion forum for subjects related to forest tree seed and seedlings in British Columbia. The link is https://spc-flnr.gov.bc.ca/SEED_TALK/. The Sharepoint site is available to all IDIR users and to SPAR clients with BCeIDs currently. Non-ministry clients need a BCeID so that they can be granted access. Subjects may include: seed policy, seed planning, seedlot information, seed orchard production, seedlot testing, seedlot germination in nurseries, seedlot and seedling performance after planting, pest management in orchards and similar topics.

6.0 Operational Tree Improvement Program

Jack Woods

The objective of the Operational Tree Improvement Program (OTIP) is to increase the quality and quantity of select seed produced from existing industry and Ministry of Forests, Lands and Natural Resource Operations seed orchards.

To meet this objective, a Call for Proposal process is administered each year in support of FGC objectives and based on priorities developed by the Interior and Coastal Technical Advisory Committees. FGC committees review and rank these proposals based on technical merit, impact, value and costs.

As a result of this work, the Land Based Investment Strategy Tree Improvement Program is supported through key investments in:

- Boosting genetic gain in seed orchards through grafting, ramet removal and replacement, and pollen management
- Boosting seed production through induction, pest management and supplemental pollination, and
- Supporting technical projects that address issues preventing orchards from meeting production objectives

OTIP uses a performance measurement system to monitor progress and set reasonable targets for project success. This year, as in past years, - - funders and researchers have responded to this approach and have achieved and exceeded planned targets.

For additional information regarding th budget and key performance indicators, please refer to the FGC Annual Report 2011/2012 at http://www.fgcouncil.bc.ca/docs/annl

6.1 Orchard Projects

6.1.1 Saanich Forestry Centre (WFP)

Annette van Niejenhuis

Western Forest Products (WFP) manages two seed orchards for forest regeneration programs in the Maritime zone at the Saanich Forestry Centre on the Saanich Peninsula. Our orchards include low and high elevation Douglas-fir, low elevation western redcedar, low and high elevation western hemlock, and low elevation Sitka spruce seed orchards as well as yellow cypress hedge orchards. As a collaborator in the Forest Genetics Council programs, WFP receives OTIP funds to implement incremental orchard management techniques to deliver quality seed in quantity to the coastal forest regeneration programs.

Low Elevation Coastal Douglas-fir Crop and Orchard Enhancement

Revised scores for a number of established orchard parents were received, resulting in revisions to orchard plans. Replacement grafts (117) were purchased. Ten ramets were replaced in orchard 405 in the third quarter. In the fourth quarter, planning and site preparation was undertaken for ramet replacement in the first month of the following year. Nutrient management continued with fertilization of replacement stock for good crown development. Significant fencing work to maintain a deer-free orchard is now complete at WFP's expense.

Phenological and reproductive bud surveys together with pollen monitoring were used to determine the male parental contribution to the seed crop. Supplemental mass pollination was implemented for early and late clones.

Gemmine spp. cysts exceeded the threshold; thus, a control treatment was applied in early May. The 2012 cone crop yielded 39.4 hl of cones for 11.3 kg of seed with an estimated 25% pollen contamination resulting in a Genetic Worth of 9.

High Elevation Douglas-fir Orchard Enhancement

Forty-five grafts were purchased early in the year. Revised scores for a number of parents were subsequently received, resulting in changes to the orchard plan and requirements for further grafting. Nineteen ramets were planted in the orchard. Nutrient management for the promotion of good crown development continued. Significant fencing work to maintain a deer-free orchard is now complete at WFP's expense.

Western Redcedar Crop and Orchard Enhancement

Seventy-five grafts were purchased to continue the upgrading of the redcedar orchard. Forty-two large ramets from the hedging bed were planted, increasing the orchard breeding value from 17.0 to 18.6. Nutrient management of the replacement stock continued.

The 2011 cone crop showed poor seed set with high seed insect infestations. The crop was not harvested. The reproductive bud surveys for the 2012 crop indicated an average crop. Supplemental mass pollination was implemented between February 23 and March 1.

Cembrix dimicrons showed light midge infestation. One pesticide application was not required.

High Elevation Western Hemlock Orchard Enhancement

As seed demand for high elevation western hemlock has increased in the past years, many years' seed supply of good genetic quality is currently banked. OTIP funds were approved only to maintain the replacement orchard for future high gain crops. This included mowing trips and applying fertilizer. However, at our expense WFP planted 8 replacement ramets in orchard 187. Additionally, we implemented a supplemental mass pollination program in the 2012 crop. Seed for potentially 20 k plantables and a genetic worth of 11 was harvested.

Similarly, significant amounts of low elevation western hemlock seed of good genetic quality is banked. Until work is undertaken to raise the average breeding value of the parents in the WFP orchard by rogueing and replacing ramets, no OTIP activities are taking place.

[illegible]

A large supply of good genetic quality seed is banked from the 2010 crops of the Maritime west Sitka spruce orchards. Only orchard maintenance and foliar pest management activities were approved for OTIP funding. Orchard replacement work was facilitated. Cone-aphid surveys indicated populations levels below treatment thresholds, and no other foliar insects showed significant presence so treatments were required.

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Hedge maintenance of the high gain orchard continued with fertilization treatments and a pesticide treatment for tortricoin moths. Sixty seven forest plants were added to the orchard to fill vacancies. Light cop pruning of flowers to maximize cuttings production was undertaken. Cuttings material for an estimated 2,45 6 plantlets with genetic worth of 20 was produced. Propagation for a replacement hedge was initiated in a rooting trial to confirm that the selected good rooters continue to perform.

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Orchard Management Operations to Enhance Productivity and Genetic Gain in High Elevation Western Hemlock Orchard #196 (SPU 2456)

The Achievement was to maintain the health and vigour of the High Elevation Hemlock Orchard #196 to produce a healthy orchard capable of producing high seed yield ***and*** *volume of genetic worth of greater than 0.*

A total of 236 orchard ramets were managed using appropriate *cultural practices over the growing season. Management included* pest identification maintenance, foliar nutrient sampling and analysis, nutrient prescription preparation, and fertilizer applications to meet nutrient needs. Cone crop surveys were also conducted to determine health and compatibility. Top and inner-whorl pruning and crown management work, where required, was completed on all ramets to initiate potential cone producing sites. No grub scouting was required this year. Pest surveys were conducted; no pest control measures were required this season.

The Tree Seed Centre has reported that a total of 5.65 kilograms of seed with a breeding value of 0 was produced in the 2011/12 season. This suggests that the crop management strategies adopted for this orchard are leading to positive contribution to attaining the objectives identified in the project application. The management strategies adopted will be continued in future years.

Photo 35. Orchard 196 western hemlock cones.

Photo 36. Orchard 196 western hemlock pollen.

6.1.4 Kalamalka Seed Orchards

Chris Walsh

In 2011/2012, Kalamalka Seed Orchards received OTIP approval for 11 projects under the operational production sub-program. The funding allowed for a significant enhancement of the effectiveness of our orchards in delivering improved seed. Activities included:

- Improving orchard composition through grafting higher breeding value ramets, maintaining recently grafted high-value ramets destined for orchards, and transplanting the older higher-value ramets to the orchards;
- Improving orchard seed quantity and quality through cone induction and pollen management, including collecting high-breeding-value pollen from clone banks and applying Supplemental Mass Pollinations; and
- Improving orchard productivity through pest and other management activities.

Orchard Quality and Quantity Boosting Activities by Project

Project	Species	SPZ	Orchard	Rootstock	Grafts Made	Maintained	Transplants	Induction
SPU04401	Sx	NE	305			41	18	
SPU05502	Sx	NE	306			8	12	
SPU07701	Pli	NE	347			208	15	
SPU11501	Pw	KQ	335	200	25	159	34	
SPU17081	Pli	BV	230		200		457	
SPU22201	Fdi	NE	324					473
SPU35501	Sx	BV	620			21		175
Totals				200	225	437	536	648

Table 1. Orchard Quality and Quantity Boosting Activities by Project.

Pollen Management Activities by Project

Project	Species	SPZ	Orchard	Pollen Collected (litres, dry)	Trees Pollinated
SPU07701	Pli	NE	307	3.0	1,499
SPU11501	Pw	KQ	335	3.0	1,870
SPU17081	Pli	BV	230	5.0	869
SPU22201	Fdi	NE	324	2.0	
SPU32201	Pli	EK	340	3.0	1,623
SPU35501	Sx	BV	620	2.5	
SPU39901	Fdi	EK	336	1.0	
SPU44401	Sx	NE	341	2.0	
Totals				21.5	5,861

Table 2. Pollen Management Activities by Project.

Plate 35. Pollen monitoring.

Operational Pest management activities at Kalamalka Seed Orchard

- monitoring pest levels to make informed decisions regarding control,
- using Safer's Soap sprays to control adelgids in Sx and Fdi,
- removing weevil-infested spruce leaders to reduce weevil populations,
- removing pine pitch moths damaging orchard tree stems,
- baiting for control of rodents feeding on tree roots,
- sanitation picking of cones in orchards with non-collectible crops to reduce pest populations,
- spraying to control *Dioryctria* in Pw,
- spraying to control mites in Fdi,
- applying dormant oil to control larch adelgids, and
- spraying to control *Leptoglossus* in Pw and Pli.

Other funded management activities to boost productivity and gain included foliar analysis to determine the nutrient status of orchard trees and crown management of orchard trees.

The OTIP funding was instrumental in increasing both the quantity and quality of seed produced. At Kalamalka in 2011 we produced approximately 112 kg of western larch, lodgepole pine, and western white pine seed equivalent to over 16 million seedlings with an average GW of +15. Large areas of the interior of the province are using Kalamalka seed.

Protecting Orchard Trees from Mountain Pine Beetle (MPB) Attack at Kalamalka (4057E29)

Gary Giampa

In 2011 our objective was to protect 4679 trees in four orchards from MPB attack in order to preserve seed production capacity. We also protected 151 Pli pollen donors in the Research Branch blocks.

In consultation with the Interior Seed Orchard Pest Management Biologist, we applied Sevin XLR insecticide to tree boles in these four pine orchards before the 2011 MPB flight. We also undertook an Integrated Pest Management (IPM) monitoring program to continuously evaluate the efficacy of the pre-flight spray through the growing season. The monitoring program was comprised of twice-weekly checks of pheromone traps to detect new flights of beetles dispersing into the orchards and regular orchard tours to detect new attacks on orchard trees.

The end result was that no seed orchard pine trees were lost to MPB in 2011.

Protecting Kalamalka Seed Orchard Pine Trees from Red Turpentine Beetle (RTB) Attack

Gary Giampa

In 2010 RTB attacks were recorded at five North Okanagan seed orchards. Ramets were killed by RTB at most of these locations. In 2011 it was necessary to monitor for these pests and protect valuable seed orchard trees. Lodgepole pine, white pine and Ponderosa pine seed orchard trees are all vulnerable to RTB attack.

In 2011 our RTB control program consisted of a three stage approach.

1. We monitored 10,002 trees for evidence of RTB attack.
2. We sprayed 2317 Pli ramets in Bailey orchard 340 with Sevin XLR bole sprays. The mature trees in orchards 230, 307 and 335 are considered to be large enough to survive RTB attacks. However, ramets in Pli 340 are of a size and age that are easily girdled and killed by RTB.
3. After spraying we surveyed all 10,002 ramets to assess the efficacy of our control program and to monitor for further attack.

The end result was that no seed orchard pine trees were lost to RTB in 2011.

6.1.5 Vernon Seed Orchard Company (VSOC)

Dan Gaudet

Operational Tree Improvement Program (OTIP) has once again provided funding for seed orchard production companies to successfully produce improved seed for Industry and the Province of BC.

Increased key indicator values have helped streamline the review process and determine successful application approvals easier than in previous years.

Vernon Seed Orchard has been diligent in fulfilling contract obligations through required reporting mechanisms. This has been very successful in assuring continued growth and accountability for this vital provincial program.

SPU 1202 Enhancing the Effectiveness of Prince George Orchard 222

Lodgepole pine is a crucial species for Northern BC and seed production levels need to increase through ramet development and increased future production levels. VSOC has begun to replace and increase production trees to reach target level demands set out by the FGC and will continue to develop and pursue silviculture demands through grafting strategies and forward selection parent trees.

1500 ramets grafted - 2918 ramets held over winter for planting in 2012/13 and insect control for existing orchard trees.

SPU 1208 Pollination and Pest Management in Prince George Orchard 236

4 litres of pollen from high gain parent trees were collected for SMP. This pollen will help achieve and maximize gain in potential seedlots.

Insect control, monitoring and spraying for 4500 trees was carried out.

SPU 1403 Enhancing Production in Prince George Weevil Tolerant Orchard 211 - White Spruce

Roguing out weevil susceptible trees to increase resistance was the primary work done in this orchard in 2012. Monitoring and spraying for pest were also funded.

SPU 1706 Pollination and Pest Management for Bulkley Valley Orchard 234

3 litres of pollen were collected for SMP in this orchard in 2012. Pest management work including pitch moth removal was initiated this year.

SPU 1801 Enhancing the Effectiveness of Central Plateau Orchard 218

2500 grafts were made to re-establish ramets that have not produced to date and to continue to get to seed production amounts for this large zone.

SPU 1709

Continued grafting ramet replacements for this orchard in 2012. 1500 grafts were made this spring as well as planting and overwintering previous grafts made in 2011.

500 trees were removed that weren't producing seed.

Monitoring for pest and pest management was also funded this year.

SPU 3702, 3703, 4102, 4103, 4301 Increasing Seed Production in Interior Douglas-fir Orchards 231, 232, 233, 225, 226

Douglas-fir orchard seed production has started to flourish in the Interior. Warm seasons have been instrumental in larger than anticipated seed yields. Pollen strategies, pest monitoring and inducing crops through $GA_{4/7}$ is part of the success. Control and good orchard management strategies are a must to be successful.

Over 500 trees were induced with $GA_{4/7}$ this year to promote seed production.

Costly sprays to ensure seed harvest success are vital in Douglas-fir orchards.

SPU 4202 Prince George High Elevation Orchard 239

Pest Management in Prince George High Elevation Orchard 239 is presently the only concern in this young orchard.

Spider mites, adelgids and other pest can seriously affect crop potential. Funding allows orchards to control potential losses efficiently through sprays and monitoring. VSOC had their first harvest of this seed which is in high demand.

6.1.6 Grandview Seed Orchards (PRT Armstrong)

Mike Brown

Projects 0702, 0721, 0728, 1001, 1002, 1007, 2101, and 4057E35

PRT Armstrong has 6 seed orchards in total which cover approximately 28 ha. Five of these orchards are lodgepole pine which produce seed for the Thomson Okanagan (TO Low) and the Nelson Low (NE Low). The sixth orchard is a Douglas-fir orchard which produces seed for the Nelson Low elevation.

For the 2011/12 operating year, OTIP funding was provided to assist with the enhancement of the overall cone yields, genetic value and tree health which facilitated the production of high value seed being produced. The activities covered under the OTIP funding were mechanical pollen distribution, supplemental mass pollination, pollen collection, insect and disease monitoring and control, crown management, crop statistics and rodent control. OTIP also provided funding for ongoing Mountain Pine Beetle and Red Turpentine beetle control.

In the spring of 2011 SMP was applied to orchard 321, 338 and 337 with the objective of maximizing seed set in all flowers and producing high quality seed. Three litres of pollen were collected, dried and stored from high BV clones in Pli 311. Due to a low number of trees with pollen in the Fdi, only one litre was collected from 321. Mechanical pollination with our air blast sprayer was used in the older orchards three times this season.

Gibberellic acid (GA) was applied to one third of the Fdi trees in conjunction with drought stress in an attempt to promote flowering in the following year. The number of injections each tree received was based on the assessment of the tree size and health. All information is recorded annually to create a data base for future years.

Monitoring the crop for insect pressure was ongoing through out the season. Our goal as always was to identify and address insect and disease pressure before they adversely affect cone and seed production. *Leptoglossus* was found to be higher than in the previous three years. Sevin was applied three times during the growing season to reduce their feeding impact on the cones.

We have an ongoing issue with *Dioryctria*, most obviously in the fir orchard. In 2011, an attempt was made to find a different method of control for *Dioryctria* because of the possible loss of Dimethoate which is the only registered product available to us. In May, BTK was applied to the crop trees in the fir. The final results at cone harvest showed a considerable insect infestation in the fir cones suggesting the efficacy of the BTK may be minimal or more trials to fine tune the timing of application are needed.

Yearly monitoring for RTB continued in 2011. Pheromone traps set out around the site showed a flight in early May. Once again, through OTIP funding, a bole spray was applied to all of the Pli ramets in 338, 337, 313, 311 and 308. There has been a notable decrease in the number of trees being killed through insect attacks which clearly shows the positive effect the preventative sprays have had. For the remainder of the season, the trees were monitored on a weekly basis to ensure no fresh attacks were found. Dead trees were regularly removed to be certain any eggs which may have been laid were destroyed.

MPB appeared to be on the decline throughout the 2010 season however; in 2011 rigorous monitoring was continued. Mature Ponderosa pine trees in the windbreak surrounding the PRT site continue to show insect damage. MPB and RTB were controlled through the same bole spray funded by OTIP.

Sequoia Pitch moth larva were once again removed manually with a concerted effort to address all of the Pli ramets twice during the season.

The control of gophers feeding on tree roots was minimized through the use of poison bait.

As part of a collaborative project with several orchards in the Okanagan, and with critical OTIP funding, cone development data was collected from trees in orchard 338, 313, and 311. The data collected will aid in the attempt to solve the issue of the loss of seed in cones during the month of August in the Pli orchards. Understanding the reasons behind these loses in seed will allow seed orchard managers to produce larger seed yields in years to come.

Crown management was done in the fir with topping performed on a quarter of the ramets.

The Pli TO low orchards produced 50 kg of seed with the potential to produce 5.8 million seedlings. In the Pli NE Low 6 kg of seed were produced with the potential for 700,000 seedlings. The Fdi NE Low orchard produced 0.28 kg of seed which equates to 10 thousand plantables. OTIP funding for the 2011 season has allowed PRT to protect the health of its 11,000 ramets and continue to produce the best A class seed yields possible.

Plate 36. PRT Laura applying pollen.

6.1.7 Eagle Rock Seed Orchards (Tolko Industries)

Tia Wagner

Four orchards are managed by Tolko Industries for the Thompson Okanagan seed planning zone. Three orchards, two interior spruce and one lodgepole pine, are SelectSeed partnership orchards. The projects funded by the Operational Tree Improvement Program aid in improving the quality and quantity of seed produced for the Thompson Okanagan forest community. In 2011, Eagle Rock produced seed for 3.3 million lodgepole pine seedlings for reforestation in the Thompson Okanagan seed planning zone.

SPU 16 Thompson Okanagan Pli High, Orchards 310 (Tolko) and 339 (SelectSeed), Project 1601

- Male bud and phenology surveys were completed to determine clonal contribution, timing of pollen shed and female receptivity for each clone.
- When surveys indicated optimal receptivity, pollination was promoted with the aid of a mist blower and helicopter.
- Pocket gophers were controlled by administering bait in the spring.
- Pest monitoring was completed for *Eucosma*, *Dioryctria*, *Rhyacionia* and *Leptoglossus*. Control sprays were required twice for *Leptoglossus* after 35 adults were observed in 15 minutes on June 6 and 27th.
- *Synanthedon* and *Dioryctria* were manually removed from the base of young ramets to prevent girdling and full or partial ramet loss.
- As required, duff was removed from the base of trees for ease of red turpentine beetle (RTB) monitoring and removal. No spray control was required for RTB.
- Pheromone traps for mountain pine beetle (MPB) were monitored weekly. Catches reveal the population continues to decrease. Only the traps closest to the log yard caught a notable quantity of insects. One tree was observed with minor feeding, therefore no control was required for MPB.
- Foliar samples were collected and sent to Pacific Soil lab for analysis. Lab results aid in determining accurate fertilization requirements for the following season.
- Orchard 310 was retired. Four hundred trees were rogued, chipped and removed from the site.
- Phenology and cone collection was completed for OTIP0722. Information and samples were sent to Kalamalka Seed Orchard for processing.

SPU 28 and 30 Thompson Okanagan Sx Low, Orchard 342 and Sx High, Orchard 343, Project 2801

- Due to the absence of a cone crop this season no pollen or SMP work was required.
- Monitoring for pests such as Adelgid species, *Pissodes strobi*, and *Oligonychus ununguis* was completed. Leaders containing *Pissodes* spp. were removed in June to decrease the population within the orchard.
- Gibberillic acid $_{4/7}$ was applied to induce cone production for 2012. In orchard 342, 316 ramets or 70% of the orchard was treated with GA and in orchard 343, 643 ramets or 61% of the orchard was given GA.
- Foliar samples were collected and sent to Pacific Soil lab for analysis. Lab results aid in determining accurate fertilization requirements for the following season.
- Pocket gophers were controlled by administering bait in the spring.

6.1.8 Prince George Tree Improvement Station (PGTIS)

Rita Wagner

SPU 1203, 1802, 1702

Activities are aimed at increasing the quantity and quality of lodgepole pine seed from Orchard 220 (Prince George low planting zone), Orchard 223 (Central Plateau low planting zone) and Orchard 228 (Bulkley Valley low planting zone).

Four Operational Tree Improvement Projects were conducted at the Prince George Tree Improvement Station in 2011-2012.

Phenology surveys were completed to keep track of receptivity periods which can vary considerably from year to year. Pollen flights were monitored. Outside pine pollen flight is basically non-existent due to the devastation caused by the mountain pine beetle.

October foliar samples were taken for nutrient analyses. Fertilizer applications were increased ensuring maximum ramet health.

Branch damage caused by hydraulic lifts, heavy & wet snow loads and strong winds required tree maintenance. Surveys for western gall rust, Elytroderma needle cast, Lophodermella pine needle cast, Zelleria pine needle sheath miner, Cecidomyia pitch midge, and various other insects were completed. Some topping as well as extensive bottom-branch and screw pruning was completed in all three orchards.

Lindgren traps were set up throughout the site to monitor secondary bark beetle flights (mainly Ips). Mountain pine beetle activity in the Prince George area continued to drop in 2011.

Since 2005 all three orchards had three years of very high production, two years of medium high production and two years of medium-low production. However, even the medium-low production still exceeded the PGG target forecast for each orchard. In 2011, the three provenance orchards yielded 39.571 kg of seed, the equivalent of approx. 7.9 million potential seedlings with a genetic worth of 6%.

Some squirrel trapping was required to avoid seed loss and loss of potential cone sites.

SPU 1412

Management of interior spruce clone banks at the Prince George Tree Improvement Station is designed to ensure the availability of scion to replace existing orchard ramets or develop new orchards to boost productivity and gain. The Interior Spruce Clone Banks at the Prince George Tree Improvement Station provide vital support to the orchard and tree breeding programs in B.C. The clone banks are a controlled source of scion material for the grafting of new and improved seed orchards. They contain the only copy of many of the interior spruce parent tree selections found in seed orchards and breed arboreta.

600 grafts planted within the last four years were maintained. We replaced approximately 300 temporary tags. To improve access topping of approximately 150 trees and bottom branch pruning was carried out in various clone banks.

Ongoing clone bank data base updates and creation of 1-page field maps for each clonebank were carried out.

To ensure good ramet health the following management activities were carried out in the 12,000 tree clone banks: inoculation, irrigation maintenance, fertilization, mowing and weeding/brushing, label replacement and foliar sampling. Due to a very wet season extensive headland mowing was necessary to control weeds and prevent brush from moving in. Insect (root collar weevil and spruce leader weevil) and disease monitoring was carried out to keep abreast of potential pest problems. Minimum bedding area retrofilling/mowing was carried out for maintenance of replacement clones.

Plate 37. Mowing lanes of trees with Protimeter attachment to measure moisture content.

6.1.9 Shrubbin Seed Orchards

Hillary Graham

Commodity Tree Program (vote 1411), Goals: 1.1.1, 1.1.2, 1.1.3, and 1.2.1

Shrubbin Seed orchards are comprised of 12 orchards covering 5 SPU's and 4 conifer species – interior spruce (Sx), Western white pine (Pw), lodgepole pine (Pl), and Ponderosa pine (Py). There are also extensive research plantations covering a wide variety of species and provenance. Seven Sx orchards produce seed for the Bobbin Valley, Peace River, and Nelson seed planning units. One Pw orchard produces rust resistant seed for the Kootenay Quesnel SPU and a 2nd Pw orchard is in development. The three young Pl orchards will produce seed for the Thompson Okanagan low, Nelson high, and Prince George low SPU's. These Pl orchards are still in development and not yet ready to be eligible for GIFP funding.

In 20XX/XX, 5 projects covering 8 orchards received GIFP funding for activities to maximize the yield and genetic gain of seed produced in the Sx and Pw orchards. These activities included bedding/bed maintenance, planning of grafts, cropping, insect and disease monitoring and control, and orchard control. In addition, one project provided funding for research plantation maintenance and development, and another project covered activities to monitor and control the mountain pine beetle.

Interior Spruce – orchards 301 (check), 302 (check), 303 (check), 304 (check), and 313 (check)

In the Sx West Kootenay low elevation orchard 301, 71 grafts were planted, and 65 grafts were planted in the Sx West Kootenay high elevation orchard 302. The cropping of 176 trees was delayed and all funding returned as the 16 year breeding values were not available.

For the Bobbin Valley Low orchards 207, 208, and 220, there were 132 replacement grafts planted into the orchards and another 129 replacement grafts were maintained in the bedding area. In orchard 207, 182 Lower breeding value ramets were rogued.

In the spruce orchards for the Peace River Low and mid elevation zones Orchards 212 & 213, the 72 replacement grafts were held over and maintained in the bedding area for Orchard 213, and will be planted into the orchard in 20XX. Due to lack of pollen availability, no pollen was collected.

All Sx orchards at Shrubbin were inventoried throughout the season for damage caused by insects, disease, and wildlife. Rust hazards (Cronartium occidentale) and feeder wound (Picoides pubis) attacked tops were removed from all orchards. Orchards were controlled for grazing bears. In 20XX there was no crop produced in the Sx orchards so all funding for cone and seed pest control was returned.

Western white pine – orchard 310 (check), Ponderosa Quesnel

The white pine orchard 310 was monitored for the presence of and damage caused by the pine cone borer (Dioryctria resinosella) and cankerous (Cronartium spp). Traps for these insect pests were set up and monitored for the season. In addition, insect visual surveys were done to assess for damage. A spray was required in orchard Pw 310 for control of Dioryctria cone borer cone borers. Bird netting was put on one border for cone raids to deter squirrels from feeding on the cones. The crop of 25 to 30 cones/tree dug of seed.

Research Plantations (check)

The on site research plantations and seed trees monitored for insects, disease and rodent damage. All plantations and seed trees received weed control (herbicide), and hand weeded where necessary. Rodents were controlled in all areas by poison baits. The Miller garden was maintained through watering, screening, and hand weeding. In June, the white pine Age Related Resistance Trial (ARRT) was treated for cankerous. The new Pl breed orchard site was monitored for pitch moth and cones/branches were pruned in the fall. The two others plantations were inspected in 20XX were addressed and the large debris piles were burned in the fall of 20XX.

Mountain Pine Beetle (20XX-XX)

Extensive visual monitoring was done for the mountain pine beetle (MPB) and red turpentine beetle (RTB) in orchards Pl 305 and Pw 309, as a prophylactic verbenalol spray was not applied in 20XX. The small Pw orchards were also monitored for any evidence of MPB or RTB attack. Pheromone traps were set up in the spring and checked once a week. The trap counts peaked the third week in July with five counts being over the baseline per trap. There was considerable less than counts in 20XX when many of the traps caught 1000's of beetles, and traps needed to be checked twice a week.

No orchard trees were attacked by the mountain pine beetle in 20XX.

[illegible]

[illegible]

[illegible]

6.2 Technical Support Programs

6.2.1 Increasing Quality, Genetic Gain, and Quantity of Yellow Cypress Cuttings (SPU 1113)

Mark Griffin, John Clegg, Craig Ferguson and John Russell

Introduction

This project involves increasing the quantity and quality of high value yellow cypress cuttings for the coastal program.

Objectives include:

1. to provide the cultural treatments required to improve hedge production,
2. to enhance hedge composition by replacing lower genetic value families and clones with newly tested, improved clones.

2011/2012 Highlights

Pruning of hedges occurred in June 2011. This year the pots were topdressed with Nutricote 18-6-8 type 180, augmented with applications of hi-sol.

In the autumn of 2011 there were 8066 donor plants in the operational hedge. The number of cuttings available from this hedge is currently estimated at 198,000 cuttings. Some rogueing has been done, as well replacement plants have been brought in to keep the number of plants in the hedge fairly constant.

A sampling of every clone from series 18c28c3 in the greenhouse was set to test each clone's progeniny to root. Clones will be evaluated and poor performing clones may be removed from production. Clones are being evaluated annually on an ongoing basis.

In late 2011, some 170,000 cuttings from the operational hedge were supplied for production to reforestation nurseries.

Photo 11: Part of the yellow cypress hedge at the Coastchan Lake Nursery in Sechelt.

Photo 12: Close up of yellow cypress hedge ready for pruning.

6.2.2 Estimating 2011 Pollen Contamination for Coastal Douglas-fir Seed Orchards

Joe Webber

SPU 1113

The 2011 contamination levels in coastal Douglas-fir orchards were 25.2% and 18.5% for Western Forest Products (WFP-166) and TimberWest (TW-193), respectively. These values can be explained by regional and orchard pollen loads during the period of orchard receptivity. Table 3 shows the regional and orchard receptivity period pollen loads for the period of 2005-2011. Pollen loads in 2011 (and 2010) were lower than in 2009 when the highest level of regional pollen loads and contamination were recorded (WFP data). Orchard pollen loads for 2011 (and 2010) were lower than in preceding years leading to higher contamination levels. For the last two years, contamination values at TW have been lower than those calculated for WFP. Since the regional pollen load values were similar at both orchards, lower contamination values at TW can be partially explained by the number of orchard parents (about 3000 at TW and 400 at WFP).

Like 2010, the 2011 receptivity period experienced cool, wet weather and orchard phenology progressed more slowly. This allowed the Orchard Adjustment Factor (OAF) to be calculated. The OAF is derived from the mean sum of ratios of early orchard pollen load to early regional (contaminant) pollen load. Only dates prior to orchard shed are used. In 2010, the OAF was 2.0 for WFP and 4.8 for TW. This raised the regional pollen load by the OAF and increased levels of contamination by the same factor. In 2011, the OAF was 0.38 and 0.79, respectively for WFP and TW. These values decreased the level of regional pollen load and therefore the contamination level by the same factor.

Since calculation of the OAF varies substantially by dates within and between seasons, I do not recommend its use for estimating the annual level of contamination in coastal Douglas-fir orchards. Current work by Dr. Y. El-Kassaby at UBC will confirm contamination estimates by pollen monitoring for the last five year crops at WFP using molecular DNA paternity analyses.

	Douglas-fir Orchard Receptivity 7-day Monitor Pollen Load (grains/mm^2/day) and %Contamination										
	WFP							TW			
	2005	2006	2007	2008	2009	2010	2011	2008	2009	2010	2011
REG PL	4.6	6.7	24.6	7.3	39.1	12.7	7.3	3.2	23.0	12.7	8.0
ORCH PL	96.3	54.6	114.6	48.9	85.4	27.5	29.0	28.6	67.8	63.7	43.2
%Cont											
PM	4.8	12.5	21.5	14.9	45.8	46.1	25.2	11.2	34.0	19.9	18.5
DNA (MS)	9.7	11.7	19.3	na	na	na	na	na	na	na	na
DNA (ELK)	10.5		DNA data for 2007-2011 in progress								

Table 3. Regional (REG) and orchard (ORCH) pollen load (PL) values (for orchard receptivity periods) and estimates of contamination for two Douglas-fir orchard sites using pollen monitoring (PM) and DNA paternity analyses (2005-2011).

6.2.3 Collection of Crop Statistics for Interior Lodgepole Pine Orchards

Prepared for Michael Carlson
Joe Webber

SPU0722

Seed yields (filled seeds per cone) from north Okanagan orchards (NO) have not met expectations compared with seed yields routinely realized at Prince George (PG). For the period of 2006-2009, orchard statistics from nine NO and three PG orchards were collected. In 2010, three NO and one PG orchard were replaced with six younger expansion orchards from NO. Figures 3 to 8 show the cone (Figures 3-5) and filled seed per cone (FSPC) data (Figures 6-8) for each of the six original (older) NO orchards, six younger expansion NO orchards and two PG orchards. Figures 4 and 7 also show a summary of annual statistics for cone and FSPC from eight of the original 12 orchards (2006 to 2010). Figures 5 and 8 compare the annual statistics for the six younger orchards (2010 and 2011). Figures 9 to 11 show similar data for the mean seed per tree calculated from the number of cones and the number of FSPC.

Over the period of 2006 to 2011, the trend for higher seed yields per cone but fewer cones at PG continued. Since the number of FSPC is high and remains fairly consistent at PG, variation in the number of seed per tree principally results from variation in the number of cones per tree. This has resulted in PG orchards out producing all but KAL 230 orchards. However, in 2010 and 2011, the number of seed per tree from the two original PRT orchards equalled or exceeded that from PG. This has resulted from a steady increase in both cone numbers and cone yields.

For the younger expansion orchards both cone numbers per tree and seed yields per cone were lower than the older orchards but there were notable exceptions. Both PRT 228 and Tolko 339 produced about the same number of cones per tree as that from the two older PRT and PG orchards. PRT 228 also yielded about the same number of FSPC as the other two PRT orchards which were the highest (about 15) of all NO orchards with the exception of KAL 230.

On average, bagged cones from 2011 (Figures 12 and 14) produced about 7 seed per cone more than un-bagged cones with the two KAL and two VSOC orchards showing the greatest loss. Over the six years observation (Figure 13), the loss of seed from un-bagged cones ranged from about 2 to 11 filled seed per cone. The greatest loss of seed occurred at Kalamalka. There was no seed loss from un-bagged cones at PG.

The 2010 Bag On/Off trial was repeated in 2011 (Figure 15). Each of the three NO orchards showed substantial seed losses (FSPC) beginning in late July and continuing to mid August for both years. Table 4 shows the difference between the always bagged and never bagged cones for cone dry weight (CDW) total seed per cone (TSPC) and filled seed per cone (FSPC). Seed losses were largest at KAL, less so at VSOC and least at PRT. There was little if any effect on CDW and loss (fewer than FSPC) of TSPC at all three orchards suggests bagging effects on FSPC occurred after seed development was complete. While the two years were consistent with the time significant losses occurred so was the weather patterns for the two years, i.e., cool May and June followed by warmer July and August. The question remains, does weather affect bagging results and if so what would the effect be if a warm May and June occurred?

The loss of seed from cones always bagged and never bagged was statistically significant in both years. It may be important to note that the loss of FSPC from un-bagged cones from the sampling trial were less in both years than those observed from the Bag On/Off trial which was harvested cones 2-3 weeks later. The loss of seed from cones always bagged and never bagged was statistically significant in both years (data supplied by Dr. Ward Strong, Kalamalka Forestry Centre).

Debate continues about the cause of this seed loss. One side of the argument suggest the losses are too large to be caused by insects alone. However, data collected in this sampling trial and other trials continue to suggest insect predation is an important but probably not the sole factor affecting lower than expected seed yields from north Okanagan orchards.

	CDW			TSPC			FSPC		
	KAL	PRT	VSOC	KAL	PRT	VSOC	KAL	PRT	VSOC
ALWAYS	6.2	5.8	5.2	25.4	29.0	22.1	16.3	15.9	12.2
NEVER	5.4	5.1	4.9	19.7	22.3	14.4	5.9	9.6	3.3
Difference	0.8	0.7	0.3	5.8	6.7	7.7	10.4	6.3	8.9

Table 4. Mean cone dry weight (CDW), total seed per cone (TSPC) and filled seed per cone (FSPC) from cones always bagged and never bagged (2011).

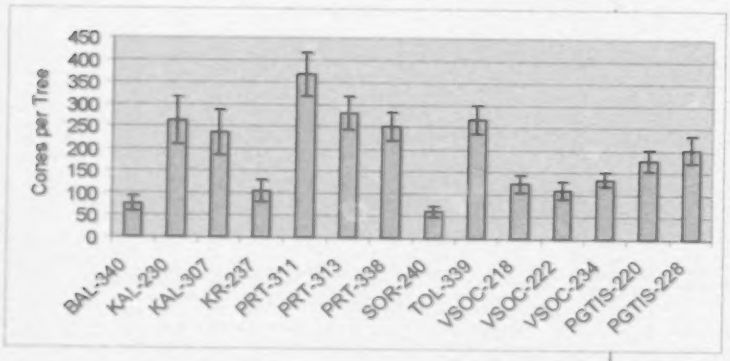

Figure 3. Mean (±standard error) total number of seed cones per ramets from each of eight original and six younger NO and two PG orchards (2011).

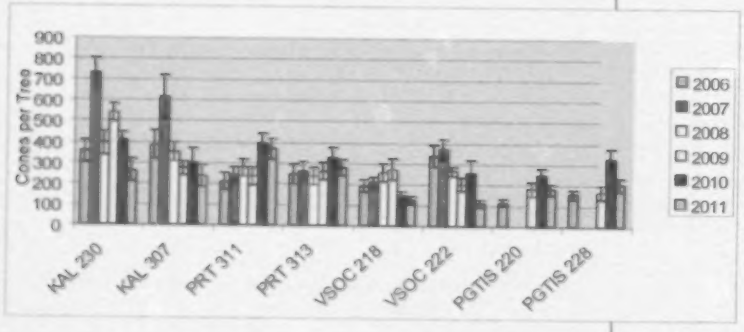

Figure 4. Mean (±standard error) number of seed cones per ramet from each of the eight original lodgepole pine seed orchards (2006–2011).

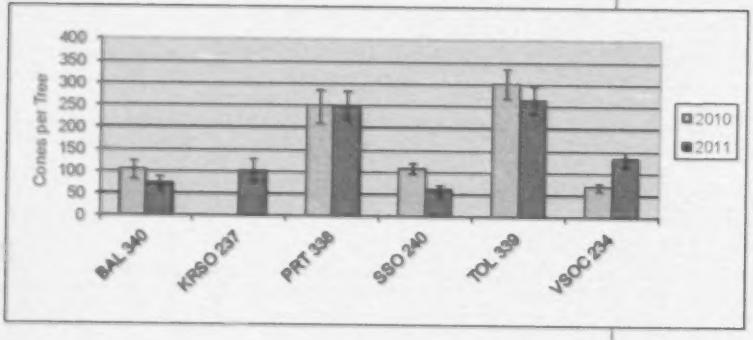

Figure 5. Mean (±standard error) number of seed cones per ramet from each of the six younger lodgepole pine seed orchards (2010–2011).

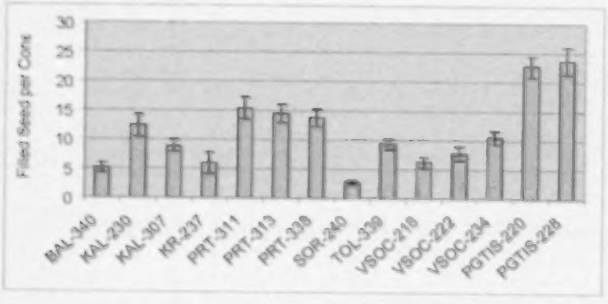

Figure 6. Mean (±standard error) number of filled seed per cone (FSPC) from each of the original eight and six younger lodgepole pine seed orchards (2011).

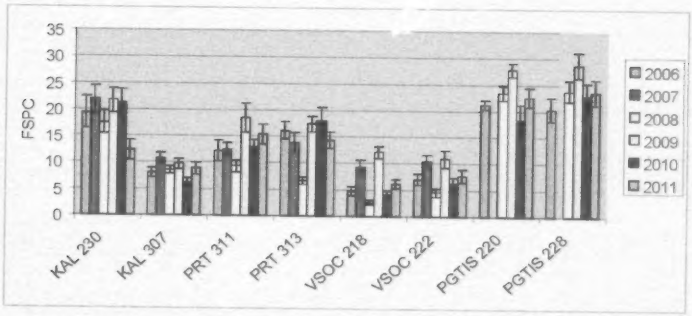

Figure 7. Mean (±standard error) number of filled seed per tree from each of the eight original lodgepole pine seed orchards (2006-2011).

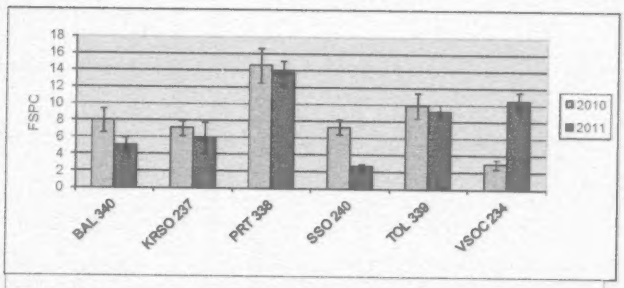

Figure 8. Mean (±standard error) number of filled seed per tree from each of the six younger lodgepole pine seed orchards (2010-2011).

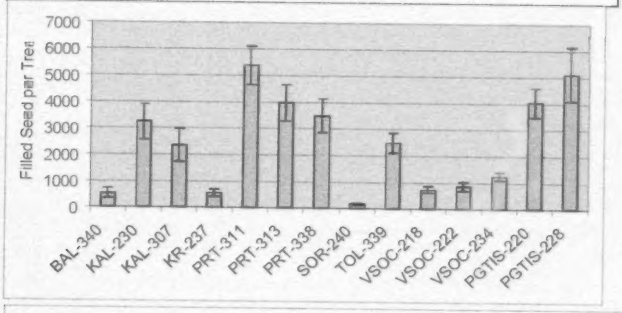

Figure 9. Mean (±standard error) number of filled seed per tree from each of the eight original and six younger orchards (2011).

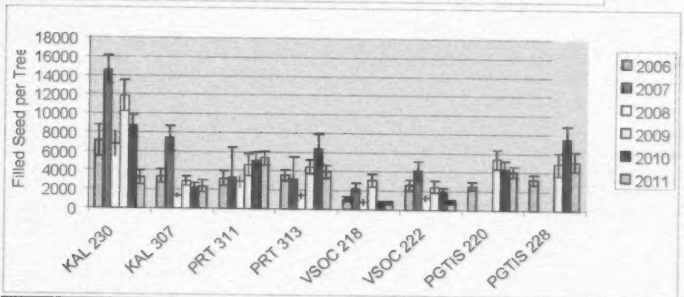

Figure 10. Mean (±standard error) number of filled seed per tree from each of the original eight lodgepole pine orchards (2006–2011).

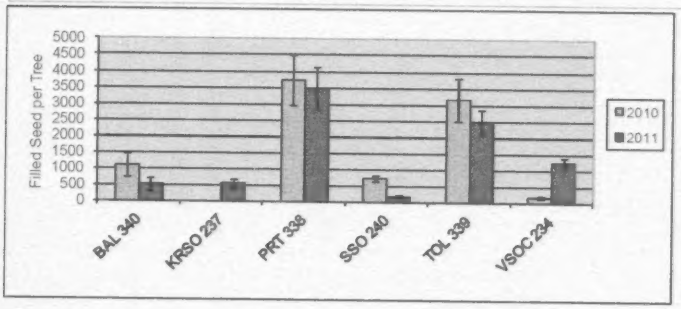

Figure 11. Mean (±standard error) number of filled seed per tree from each of the six younger lodgepole pine orchards (2010–2011).

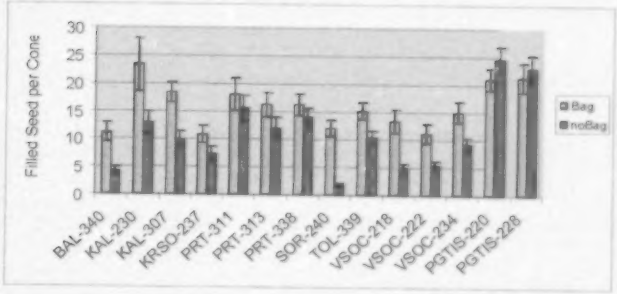

Figure 12. Mean (±standard error) filled seed per cone for bagged and un-bagged cones from the six original, six younger and two PG orchards (2011).

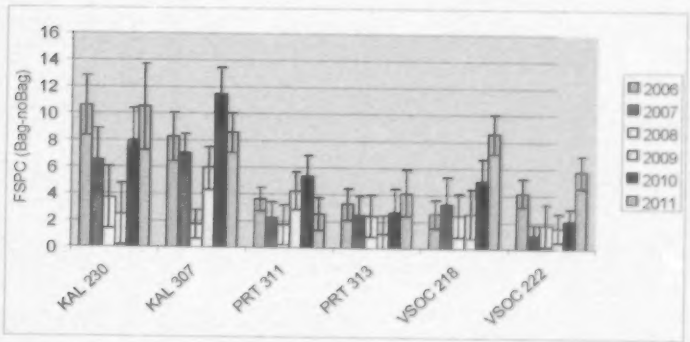

Figure 13. Mean (±standard error) filled seed per cone (FSPC) difference between bagged and un-bagged cones from the eight original NO lodgepole pine orchards (2006–2011).

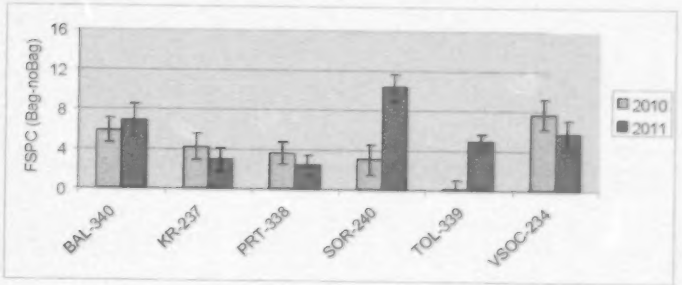

Figure 14. Mean (±standard error) filled seed per cone (FSPC) difference between bagged and un-bagged cones from the six younger NO lodgepole pine orchards (2010–2011).

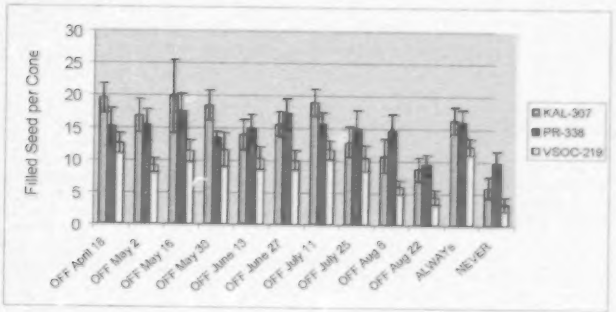

Figure 15. Mean (±standard error) filled seed per cone (FSPC) for twelve exposure periods from the 2011 Bag On/Off trial in each of three NO orchards.

7.0 Extension Technical Advisory Committee (ETAC)

Diane Douglas

Seed Orchard Pest Workshops

Kalamalka Forestry Centre, Vernon, BC, April 7, 2011

This workshop was hosted by Jim Corrigan at Kalamalka Seed Orchards with 34 in attendance. The morning was spent at Kal with presentations and in the afternoon, we toured several demonstrations set up at Kal and Bailey Road. Topics covered included: *Leptoglossus*, a fabric wrapping trial to reduce/prevent attack by pitch moths (*Synanthedon sequoiae*) on young lodgepole pine ramets and the swing-arm mower as a potential alternative to using herbicides for weed control in kill strips.

Whitebark Pine: Science and Management Forum, Lillooet, BC, July 14 & 15, 2011

The Whitebark Pine Ecosystem Foundation of Canada (www.whitebarkpine.ca)was recently formed. Their mission is the promotion and conservation of whitebark pine ecosystems by supporting restoration, education and research projects that enhance the knowledge and stewardship of these valuable ecosystems.

The foundations hosted a whitebark pine forum in Lillooet in July 2012. The Lillooet workshop was attended by about 40 individuals and was co-hosted by the Lillooet Tribal Council, Lillooet Naturalists Club and the Extension Technical Advisory committee of the Forest Genetics Council.

Topics covered were utilizing public outreach for restoration, Alberta, BC, US perspectives on Whitebark pine and research projects underway, genetic conservation, seeds, white pine blister rust, and grizzly bears and whitebark pine. The meeting was followed by a field trip to various sites in the Yalakom Valley.

Nutrient Workshop

Kalamalka Forestry Centre, Vernon, BC, October 6, 2012

Tia Wagner organized this workshop which was held at Kalamalka Forestry Centre with 36 people in attendance. A contract with Mario Lanthier from Crop Health Advising and Research to provide workshop presentations was very worthwhile. Chuck Bulmer, Soil Restoration Ecologist from Kalamalka Forestry Centre and Stephen Eng, from AAT Direct Solutions gave presentations.

Topics covered were Soil Management in Seed Orchards, typical symptoms of nutrient deficiencies in conifer plants, understanding your Tissue and Soil Reports – solutions from the wide, wide world of fertilizers. The workshops was very well received.

A big thank you to Tia Wagner!

BC Seed Orchard Association (BCSOA) meeting

The last BCSOA was held in 2007 in Prince George. The next meeting will be a joint meeting with North West Seed Orchard Manager's Association from the US, to be held in Victoria and Port Angeles, WA in June 2012. A contribution was made by ETAC for this meeting.

Publications

TIC*talk* http://www.fgcouncil.bc.ca/tictalk_2012.pdf

Plate 54. Whitebark pine: Science and Management Forum, Lillooet, participants.

8.0 Seed Orchard Pest Management

Jim Corrigan

The objective of the Seed Orchard Pest Management Subprogram is to provide research, extension support and orchard-level pest management to increase yields of high quality seed coming from the seed orchards of our province. The research and extension activities are handled through the Tree Improvement Branch of the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). Dr. Ward Strong has a half-time responsibility to conduct pest management research, while Jim Corrigan delivers extension services to Interior and Coastal operations. Seed orchard personnel handle hands-on pest management duties in the seed orchards.

The Pest Management Technical Advisory Committee (PMTAC) recommends annual funding allocations that come from the Forest Genetic Council to support relevant pest management research. Committee members are from the MFLNRO Tree Improvement Branch, the Canadian Forest Service, industry and BC government seed orchards and the Forest Genetics Council. The PMTAC establishes research priorities and budgets through an annual process of proposal development and evaluation. In fiscal 2011, the PMTAC supported projects on conifer seed bug, fir coneworm, Douglas-fir cone gall midge, novel pesticides, lab and technical research support, and cone and seed pest management extension operations.

PMTAC Projects for fiscal 2011 are summarized in Table 5.

Project	Species primarily impacted	Progress
Pesticide trials	Fd, Pw	Evaluations of foliar sprays of novel candidate pesticides for control of *Diorytria abietivorella* & *Contarinia oregonensis* in Douglas-fir, and for phytotoxicity of these pesticides when applied to Douglas-fir & white pine ramets.
Contarinia/Leptoglossus Visual Foraging Cues	Fd, Pw, Pli	In collaboration with Simon Fraser University, this ongoing study investigated the interaction of visible light, infrared radiation, and host shape in host finding by *Leptoglossus occidentalis* and *Contarinia oregonensis*.
Research lab and technical support	All species	Funding was provided for on-going lab operations and technical assistance in support of research activities.
Pest management extension operations	All species	Funding provided for on-going extension support to Interior and Coastal seed orchard locations and to the Tree Seed Centre.

Table 5. Pest Management TAC projects for fiscal 2011.

Plate 15. Large populations of Adelges cooleyi, the Cooley spruce gall aphid, starting to wood up as they attack Douglas-fir seedlings, April 2011. (Photo by Jim Corrigan).

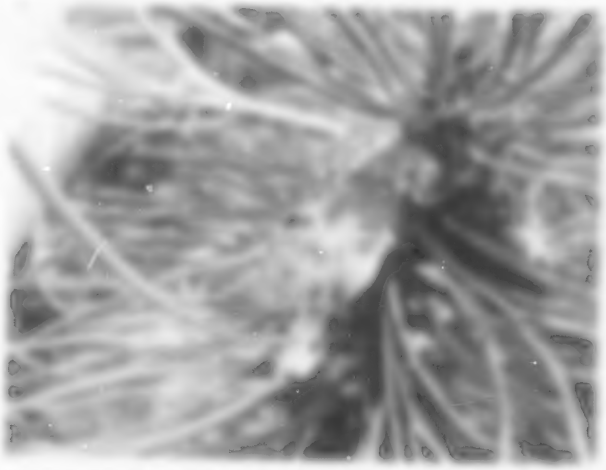

Plate 16. Nymphs of Aphrophora parallela, the pine spittlebug, feeding on a hedgeprovin pine cone, June 2011. (Photo by Jim Corrigan).

Plate 17. Late instar larvae of Dioryctria reniculella, the ponderosa pine coneworm, feeding on a hedgeprovin pine cone, June 2011. (Photo by Jim Corrigan).

Plate 18. Moths of the Douglas-fir cone gall midge, Contarinia oregonensis, caught in a sticky trap baited with host female sex attractant pheromone, May 2011. Photo by Jim Corrigan.

Appendix 1 FGC Seed Planning Unit

Seed planning unit (SPU)					Program category
#	Species	Common Name	BEC	Elev. band (m)	
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Appendix 2 Tree Species

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]

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[redacted]	[redacted]	[redacted]